ISIS

INDIVIDUALIZED SCIENCE INSTRUCTIONAL SYSTEM

KEEPING FIT

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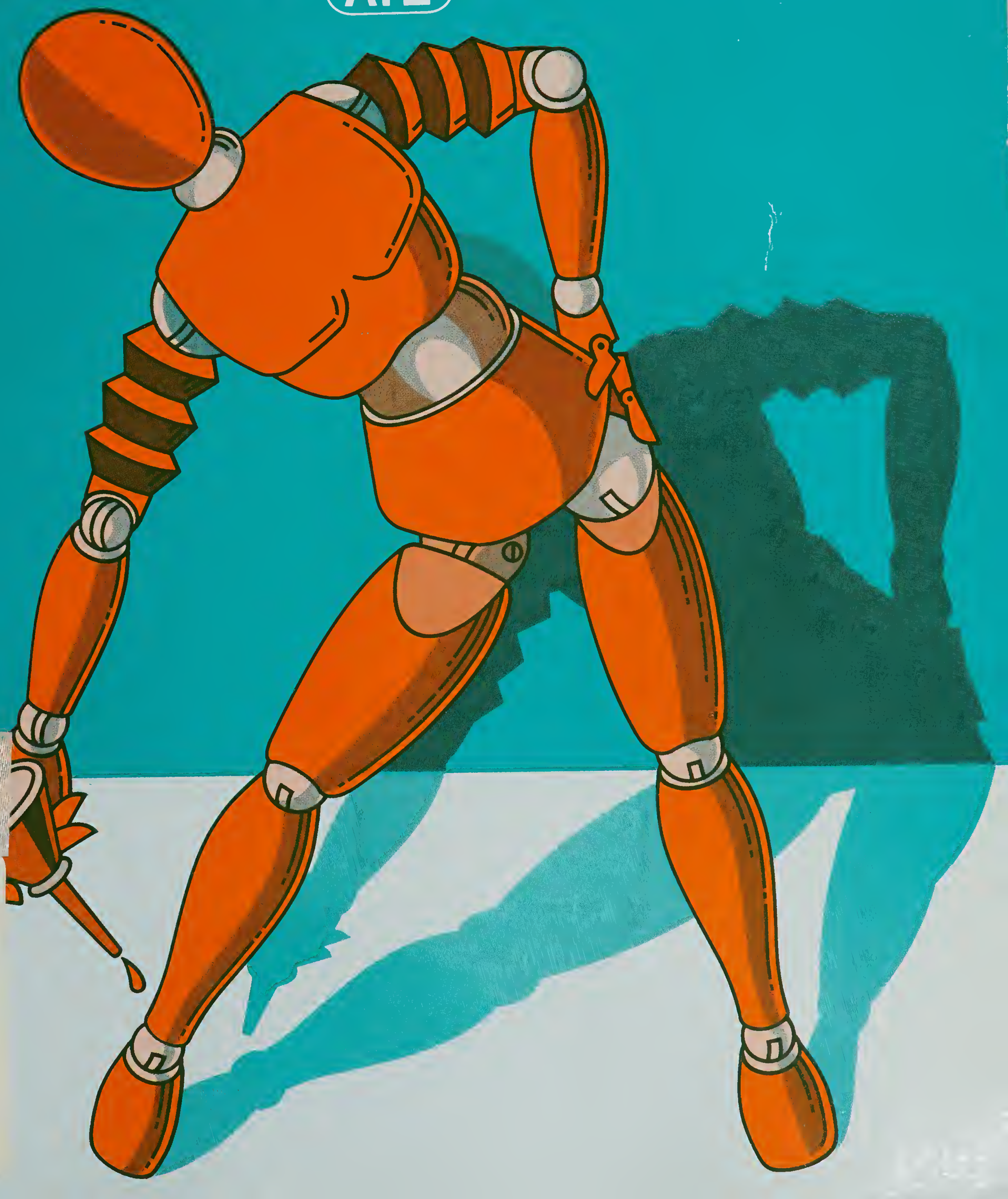

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INDIVIDUALIZED SCIENCE INSTRUCTIONAL SYSTEM

KEEPING FIT

ANNOTATED TEACHER'S EDITION

Ginn and Company

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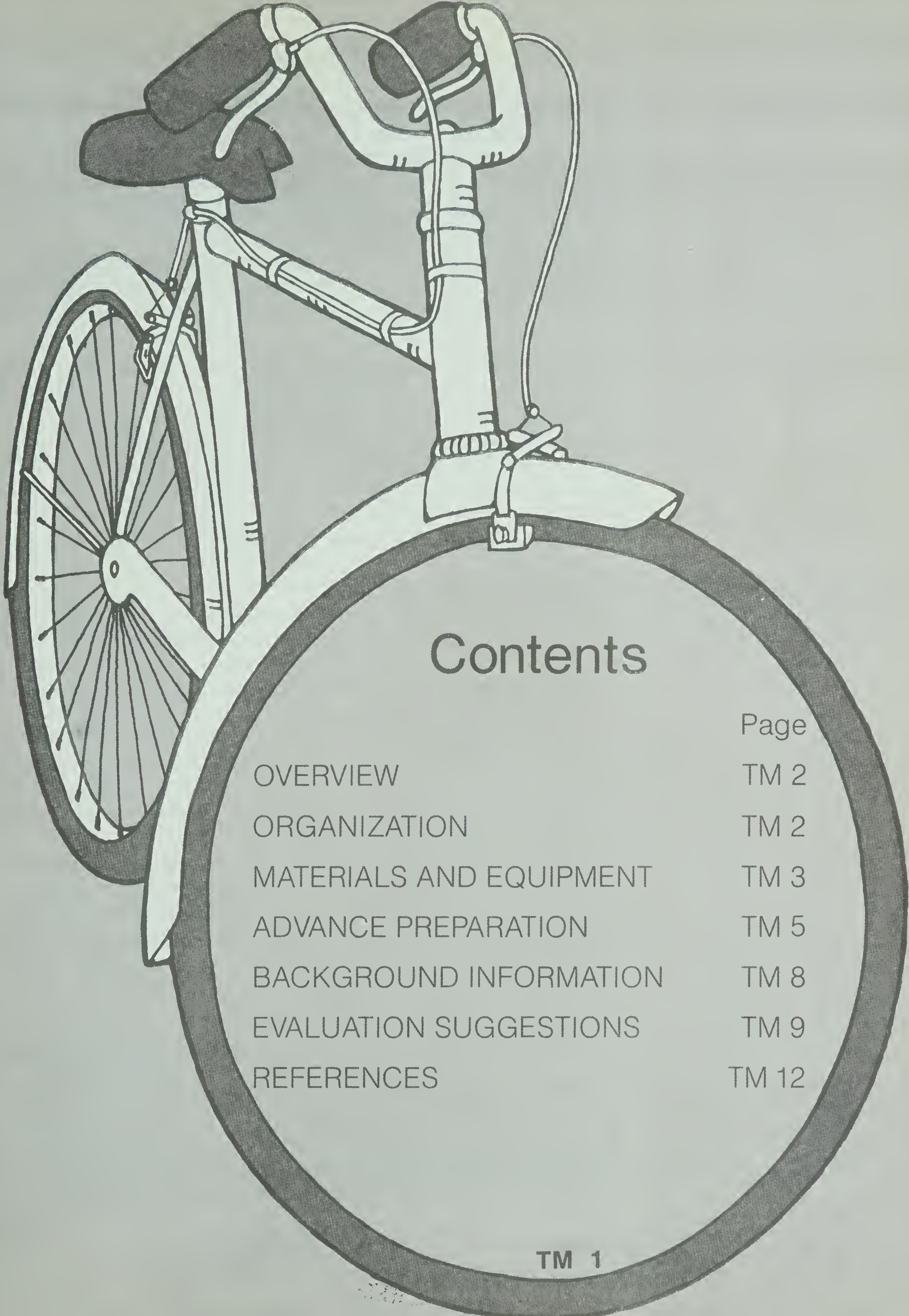


Contents

Overview

Keeping Fit deals with the support and cardiovascular systems of the human body. Students study the basic muscle and bone structures that are related to fitness, and they learn about the prevention and treatment of common muscle and joint injuries. Self-awareness is emphasized as students identify the physical traits that they're weak in and then design a program to improve those traits.

This minicourse could be part of a biology course or part of a physiology or health program. In whatever area of the curriculum it is used, *Keeping Fit* should be of interest and concern to young people.

Organization

This minicourse contains thirteen core activities, four advanced activities, and three excursion activities. The planning activity must be done first in each section. In the core section, those students who plan to do Activities 2, 3, 4, or 5 must do so right after completing the planning activity. Activity 5 is a required activity and requires 10 to 20 days to complete. It should be started early in the time schedule. Activities 6 through 13 may be done in any order.

In several core activities, students learn how to measure and to improve three physical traits: endurance, strength, and flexibility. Some core activities describe how to exercise properly and how to avoid and treat injuries to the muscles, bones, and joints. Other core activities deal with the names and functions of some major bones and with the functions of tendons and joints. In the required activity, Core Activity 5, students plan and partake in a ten-day exercise program. In another core activity, facts and fables about exercise are discussed. Students learn to find out the facts about statements rather than to believe everything they hear.

The *Class Rating Chart*, supplied separately, is used with Core Activities 2, 3, and 4. In this chart, students record their ratings for endurance, strength, and flexibility. The *Skeleton Puzzle*, supplied separately, is used with Core Activity 7. This is a crossword puzzle for which students must know the scientific names for twenty major bones.

In the advanced activities, students analyze an experiment, study a theory of muscular contraction, and study the biochemistry of muscular fatigue. The *Experiment Analysis Form*, supplied separately, is used with Advanced Activity 15. Students use this form to analyze an experiment described in Activity 15.

In one excursion activity, students learn how to determine whether an activity will affect one, two, or three traits (endurance, strength, or flexibility). They learn how to choose exercises for improving fitness

in each trait. In another excursion activity, students learn why they should warm up before exercising. They do warm-up exercises as part of an investigation to find out how their flexibility is affected by the exercises.

Materials and Equipment

The following table shows the quantity and the frequency of use of each item used in each activity. The activities that require no materials are not listed in the table.

It is important to collect and organize all the materials for each minicourse before the students begin any of the activities, since the students will be working simultaneously on different activities. Having all materials readily available allows students to do the activities in the order they choose. The amount of material you will need to make available will depend on the number of lab groups that will be doing each activity. As lab groups use the "skipping option," and as they scatter themselves throughout the activities, the total amount of materials needed at one time for each activity will decrease.

CONSUMABLE ITEMS	MINIMUM MATERIALS PER LAB GROUP PER ACTIVITY*										
	Act. 2	Act. 3	Act. 4	Act. 7	Act. 10	Act. 11	Act. 13	Act. 15	Act. 16	Act. 17	Act. 20
Cardboard sheet, stiff, 22 cm × 15 cm				1							
† *Class Rating Chart*, 1 per classroom	✓	✓	✓								
† *Experiment Analysis Form*								1			
Fasteners, paper				3							
Graph paper	1										
† Grasshopper or cricket, freshly killed									1		
Modeling clay, 1 cc						1					
Plastic bag, medium to large					1						
† *Skeleton Puzzle*				1							
String, heavy, 40 cm				2							
Tape, cellophane or masking, 15-20 cm			1								1

* A lab group is defined as one student, a pair of students, or any size group of students that you choose.

† See Advance Preparation.

Materials and Equipment (Continued)

NONCONSUMABLE ITEMS	MINIMUM MATERIALS PER LAB GROUP PER ACTIVITY*										
	Act. 2	Act. 3	Act. 4	Act. 7	Act. 10	Act. 11	Act. 13	Act. 15	Act. 16	Act. 17	Act. 20
† Bench or chair, 40 cm high	1		1								1
† Brain jug apparatus wide-mouth glass jar with lid wooden or cork block or ball string, 30 cm modeling clay, 1 cc hammer and nail						1					
Elastic bandage, 5 cm wide					1						
† Flexibility measuring stick			1								1
Forceps									1		
Glass slide									1		
Knife, sharp									1		
Mass, 1 kg, or similar object							1				
Medicine dropper									1		
Metric ruler				1							
Microscope									1		
Paper punch				1							
Rope, jumping	1										
Rug or small mat, about 1.2 m × 2.4 m		1									
Scissors				1							
Watch or clock with second hand	1	1									1
Resource Unit 1			✓								✓
Resource Unit 2	✓									✓	✓
Resource Unit 3									✓		
Resource Unit 4	✓										
Resource Unit 13							✓				
Resource Unit 15								✓			
Resource Unit 19			✓								

* A lab group is defined as one student, a pair of students, or any size group of students that you choose

† See Advance Preparation.

Advance Preparation

It is important to reserve an area where students can do the various fitness tests and exercises without disturbing others or being self-conscious. The area may be in the classroom, halls, gymnasium, or outside the building.

If the exercise area is not in the classroom, check school regulations to see if an adult must be present.

Activities 2, 3, and 4 Core pages 6, 13, and 19

The *Class Rating Chart,* needed for these activities, is supplied separately. The chart may be prepared by you or a student. Make three copies of the spirit duplicating master *Class Rating Chart.* Under the words "Class Rating Chart," write *Endurance* on one copy, *Strength* on another, and *Flexibility* on the third. Join the three copies with tape so that they form one horizontal chart.

Display the chart where students can write on it. It should be kept on display until all students have completed the minicourse. A student records a rating by darkening or shading the first available box that appears in the column for the rating.

When all students have completed the minicourse, you may want to turn the chart upside down. If there are enough ratings recorded, the darkened boxes in each section of the chart should form a pattern that resembles the normal curve. This should reinforce the fact that most people are average for physical traits.

Activity 2 Core page 6

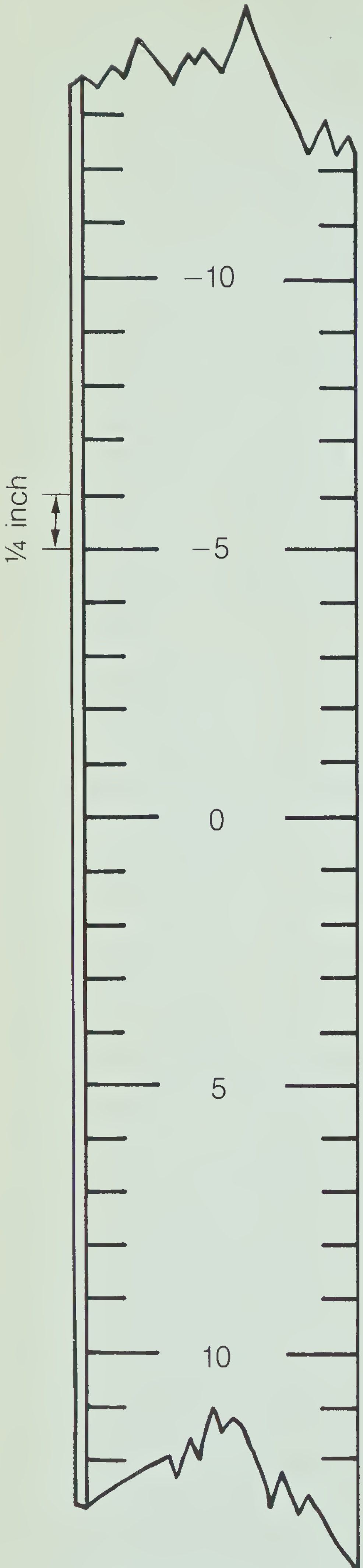
To evaluate cardiovascular endurance, it is absolutely essential that the seat of the bench or chair, used for the Step Test, be 40 centimetres above the floor. Any other height would invalidate the test, and a student's fitness would be either underestimated or overestimated. The bench or chair must be strong enough to support the heaviest student and stable enough not to tip over during the test.

A student interested in woodworking might build a bench for the Step Test, or shorten the legs on a wooden chair so that the seat is the correct height. Another alternative is to arrange cinder blocks so that they are the proper height, and cover the tops of the blocks with a sturdy board.

The *Class Rating Chart*, supplied separately, is needed for this activity. For directions on preparing the chart, see the advance preparation for Activities 2, 3, and 4.

Activity 3 Core page 13

The *Class Rating Chart*, supplied separately, is needed for this activity. For directions on preparing the chart, see the advance preparation for Activities 2, 3, and 4.



Flexibility Measuring Stick
Figure 1

Activity 4 Core page 19

The seat of the bench or chair for the Toe-Touch Test must be exactly 40 centimetres above the floor. The bench must be strong enough to support the heaviest student and stable enough not to tip over during the exercise. For suggestions on preparing the bench, refer to the advance preparation for Activity 2.

A flexibility measuring stick is needed for this activity. The stick may be prepared by you or a student. Use a strip of wood or cardboard, at least 45 cm in length. Mark one-fourth-inch intervals on the stick, as shown in Figure 1. (One-fourth-inch intervals were used for the national norms and must be used here to make the students' comparisons valid.) Label the mark that's near the middle of the stick *0*. Then, as in Figure 1, use *5, 10, 15,* etc., to label every fifth mark below *0*; use *–5, –10, –15,* etc., to label every fifth mark above *0*.

Avoid using a ruler for a flexibility measuring stick since the numbers and markings on the ruler might confuse the students.

The *Class Rating Chart*, supplied separately, is needed for this activity. For directions on preparing the chart, see the advance preparation for Activities 2, 3, and 4.

Activity 7 Core page 31

You may wish to have a bone sample or skeleton available so that students may observe bone structure more closely. Quarter-sections of human humerus are available from several sources. One such source is: Mogul-Ed, P. O. Box 2482, Oshkosh, WI 54901.

Each student doing this activity will need a copy of the *Skeleton Puzzle,* supplied separately. Be sure to have enough copies available.

Activity 11 Core page 48

A "Brain Jug" is needed for this activity. Either you or a student can construct it with the following equipment:

glass jar with lid (wide-mouth jar about the size of a soup can)
wooden or cork block or ball that "just fits" inside the jar
string, about 30 cm
modeling clay, 1 cc
hammer and nail

Make a hole in the middle of the lid by hammering a nail through it. Fasten one end of the string to the block or ball. Thread the other end of the string up through the underside of the lid. Hold the string that's threaded through the lid and put the lid on the jar. Adjust the string so that the block dangles 2 cm or more above the bottom of the jar. (See Figure 2.) Fasten the string by taping the end to the top of the lid, or by tying a large knot in the string, right above the hole in the lid. Take

off the lid and fill the jar with water. Then place the block in the water and fasten the lid on the jar. Seal the hole in the lid with modeling clay so that water won't leak out when the jar is turned upside down.

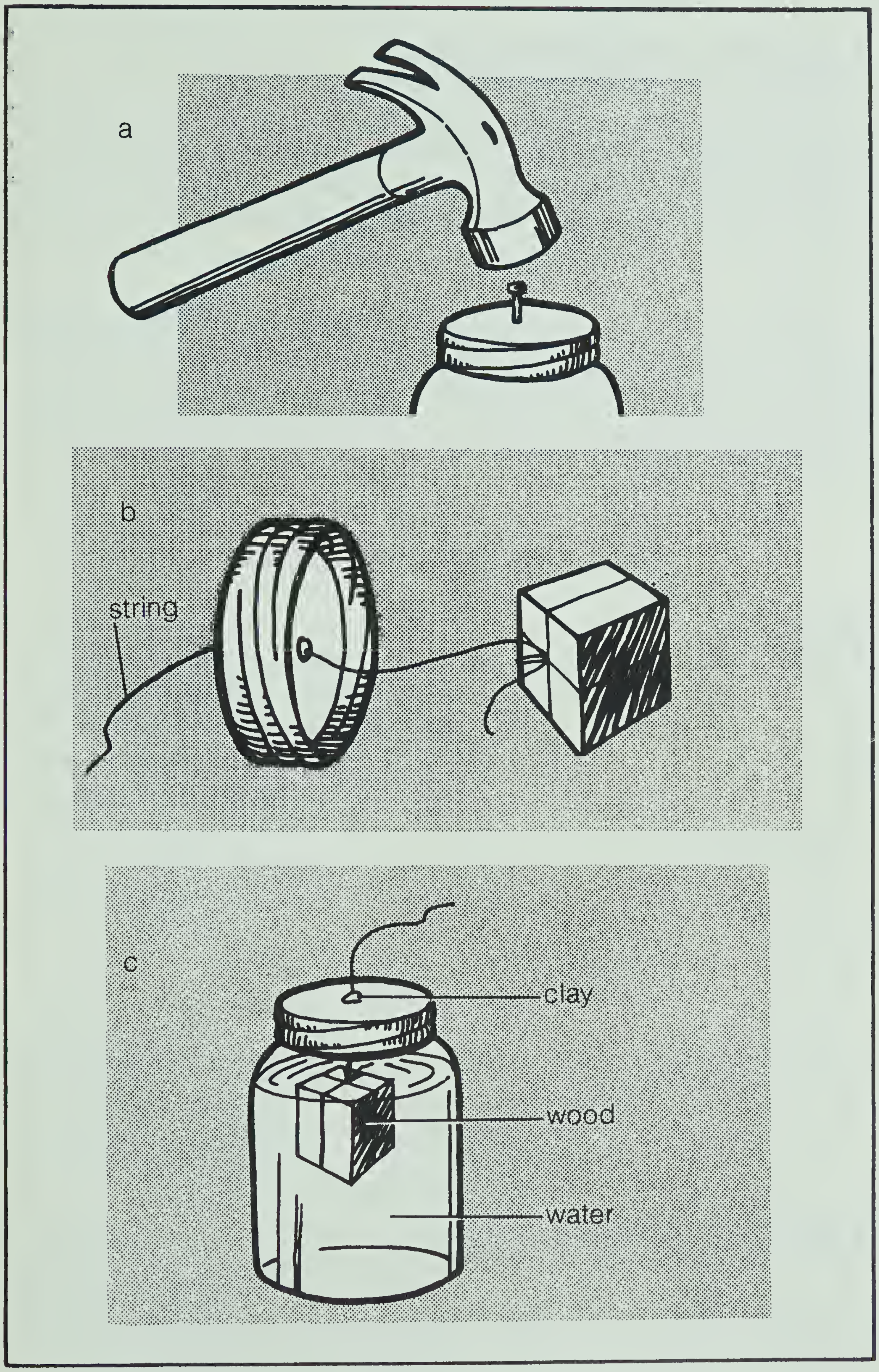


Figure 2

Activity 15 Advanced page 58

Each student doing this activity will need a copy of both pages of the *Experiment Analysis Form*, supplied separately. Be sure to have enough copies available.

Activity 16 Advanced page 60

Freshly killed grasshoppers or crickets are needed for this activity. Live insects may be available locally, or can be ordered. If you order them, be sure to do so well in advance so that they will arrive in time for the students to use. Be sure to keep the insects alive until the students do the activity. To kill the live insects, put them in 25 ml of 70% alcohol for 2 minutes. Do this right before the insects are to be used.

Freshly killed insects are better to use than preserved insects, because the striations in the muscle fibers show up better. However, if it is not possible to get live insects, preserved ones can be used. With preserved insects, students should get a general idea of how the striations look.

Background Information

General Cautions

In the planning activities, students are directed to check with their teacher if they feel they cannot do vigorous exercises. Rather than leave it up to students to evaluate their health, you might check with the school nurse or the physical education department to see if any students have a medical problem that would preclude their doing the exercising parts of this minicourse.

Students recovering from an illness should wait until they are in normal health before they do the exercises. Students who are in poor physical condition, but healthy enough to *try* the exercises, may be excluded from the evaluatory aspects of the activities. These students should be cautioned against trying to do strenuous exercises.

In *Keeping Fit,* there are a number of hints for health and general well-being. There are also some suggestions about first aid. Students should be warned against any tendency to dispense medical advice, such as serving as surrogate trainers or doctors, or otherwise presenting themselves as medical authorities.

Heart Rate During Exercise

Students may ask why 150 beats per minute is the recommended intensity, during conditioning, for the heart of a person 15-25 years old. This intensity is based on the work of the physiologist M. J. Karvonen. Karvonen used a treadmill for investigating endurance training. He found that the greatest improvement in endurance was

achieved when a person exercised at a heart rate that was 60% between the resting and maximum heart rates. Since the average 15- to 25-year-old has a resting heart rate of about 70 and a maximum heart rate of about 200, his or her exercising heart rate should be about 148, or 150 (rounded off).

$$70 + 60\% \text{ of } (200-70) = 70 + 78 = 148$$

If students don't want to use this average heart rate (148 or 150), they may use Karvonen's formula to find their own rate. (A maximum heart rate may be obtained by taking pulse after sprinting for 200 yards.)

National Norms, Sex Differences

The norms used for sit-ups were modified from norms published by the Governor's Commission on Physical Fitness, the State of Texas, 4200 N. Lamar, Suite 101, Austin, Texas 78756. Also available from the same source are norms for the flexed arm hang, chin-ups, dips, the 12-minute run/walk for distance, the 1.5-mile run/walk for time, the timed 50-yard sprint, the 8-second dash, shuttle run, zig-zag run, vertical jump, and broad jump.

It may be of interest to students that different factors are used for males and females in some norm tables and not in others. For example, age seems to be the main determiner for a male's strength, but body weight is the determiner for a female's strength. And neither age, weight, nor sex are factors in determining endurance.

Sex differences are also important in terms of the way muscles change during conditioning. The process of muscle fibers getting bulkier through exercise seems to be related to testosterone levels in the body. Hence bulging muscles are much more prevalent in males than in females, but still vary from person to person.

Evaluation Suggestions

In addition to the Minicourse Test, you might use some or all of the following suggestions to evaluate your students.

Essay Questions

Five essay questions and their possible answers follow. The first four questions are related to core activities, and the last question is related to the advanced activities.

1. In planning a fitness program, you should consider frequency, intensity, duration, and warm up. What do these terms mean and why are they important?

Answer: *Frequency* refers to how often you should exercise. Without regular exercise (preferably every other day) little or no improvement will occur. *Intensity* refers to how hard you should exercise. Improvement results when muscles are "pushed" to do a little more than they usually do. *Duration* refers to how long you should exercise. Exercising for 15-30 minutes allows maximum improvement. *Warm up* means to do light exercises right before an activity. After you warm up, your muscles produce more energy and your flexibility is increased.

2. Describe the important changes that take place in your heart, muscles, bones, and tendons as you get in shape.

Answer: As you get in shape, your *heart* grows slightly larger and stronger. It pumps more blood with each beat. Your *muscles* get stronger as the muscle fibers get larger and more fibers are used. Your *bones* get stronger as more bony bars develop within the bones and act as internal support. Your *tendons* become more flexible allowing more freedom of movement in your joints and less chance of injury to your joints.

3. Explain the role of the muscles, bones, tendons, and joints in moving your body.

Answer: *Muscles* and *bones* work together to move your body. The muscles that move your bones work in pairs. They take turns pulling on a bone to raise and lower it. When one muscle in a pair pulls on a bone, that muscle contracts and gets shorter. The other muscle in the pair relaxes and gets longer.

Tendons connect muscles to bones and always cross a joint (where two bones meet). When your tendons and muscles are flexible, your *joints* are flexible. Then your body can move easily and freely, and there is less chance of injury to your joints.

4. Describe the relationship of warm up to each of the possible types of injuries:

muscle pulls
sprains
dislocations
spinal cord injuries

Answer: Warm-up exercises generally tend to increase the flexibility of muscles, tendons, and ligaments. When these structures are flexible, they're not likely to be injured during strenuous exercise. Specifically, warmed-up muscle fibers are less likely to tear during stress, so *muscle pulls* are less likely to result. Warmed-up tendons and ligaments are less likely to tear or overstretch during stress, so

sprains are less likely to result. And when the tendons and ligaments around a joint are warmed up, they are better able to accommodate stress. Thus, the joint is more flexible so *dislocations* and *spinal cord injuries* are less likely to occur.

5. Describe the two energy-producing processes in muscles. Use as much detail as you can in your description. Then tell which energy-producing process is used and what happens during recovery for (a) a 400-meter race and (b) a basketball or soccer game.

Answer: Both processes start with the breakdown of glycogen to pyruvic acid. Then if there's enough oxygen present in the muscles, the pyruvic acid goes through the aerobic process. Large amounts of ATP are formed and CO_2 and H_2O are produced. If there's not enough oxygen in the muscles, the pyruvic acid goes through the anaerobic process. Small amounts of ATP are formed and lactic acid, a waste product, is produced.

(a) During a 400-meter dash, most of the energy is produced anaerobically. During recovery, the muscle cells convert some of the excess lactic acid to CO_2, H_2O, and ATP. The liver converts the rest of the excess lactic acid to glycogen.

(b) During a basketball or soccer game, most of the energy is produced aerobically. During recovery, the body produces glycogen to replace the glycogen that was used.

Performance Items

The following items require individual students to demonstrate a skill. The first two items are related to the core activities, the third item is related to an excursion activity.

1. On your wrist, demonstrate a method for taking pulse.

Answer: Student should demonstrate the method shown in Figure 2-1, Activity 2.

2. Demonstrate a method for measuring your (a) endurance, (b) abdominal muscle strength, and (c) flexibility.

Answer: Student should demonstrate the methods described in Activities 2, 3, and 4.

3. Demonstrate four warm-up exercises.

Answer: Student should demonstrate four of the exercises shown in Figure 20-4, Activity 20.

References

Astrand, P. O., and Rodahl, K. 1970. *Textbook of work physiology.* New York: McGraw-Hill.

This is an advanced college textbook which is suitable as a reference for teachers.

Grollman, S. 1974. *The human body: Its structure and physiology.* New York: MacMillan.

This is an advanced textbook on human anatomy and physiology. It is most suitable for teachers.

Hoyle, Graham. 1970. How is muscle turned on and off? *Scientific American.* 222: 84-93 Ap.

The article is on the effect of calcium ions on muscle fibers of giant barnacles. It is for advanced students.

Huxley, H. E. 1965. The mechanism of muscular contraction. *Scientific American.* 213: 18-27 Dec.

A detailed discussion is presented and is most suitable for teachers. Huxley is the leading experimenter and theorist in this area.

Margaria, Rudolfo. 1972. The sources of muscular energy. *Scientific American.* 226: 84-91 Mar.

Information is presented on biochemical processes and fatigue.

The following book is available from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20401

President's Council on Physical Fitness and Sports. 1973. *Youth physical fitness.* 4000-00297.

This is an excellent resource for both teacher and student. Its purpose is to assist in the promotion of effective physical education programs.

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In addition to the major effort by the ISIS permanent staff, writing conference participants, and author-consultants (listed on the inside of the back cover), the following contributed to this minicourse.

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foreword

Evidence has been mounting that something is missing from secondary science teaching. More and more, students are rejecting science courses and turning to subjects that they consider to be more practical or significant. Numerous high school science teachers have concluded that what they are now teaching is appropriate for only a limited number of their students.

As their concern has mounted, many science teachers have tried to find instructional materials that encompass more appropriate content and that allow them to work individually with students who have different needs and talents. For the most part, this search has been frustrating because presently such materials are difficult, if not impossible, to find.

The Individualized Science Instructional System (ISIS) project was organized to produce an alternative for those teachers who are dissatisfied with current secondary science textbooks. Consequently, the content of the ISIS materials is unconventional as is the individualized teaching method that is built into them. In contrast with many current science texts which aim to "cover science," ISIS has tried to be selective and to limit our coverage to the topics that we judge will be most useful to today's students.

Obviously the needs and problems of individual schools and students vary widely. To accommodate the differences, ISIS decided against producing tightly structured, pre-sequenced textbooks. Instead, we are generating short, self-contained modules that cover a wide range of topics. The modules can be clustered into many types of courses, and we hope that teachers and administrators will utilize this flexibility to tailor-make curricula that are responsive to local needs and conditions.

ISIS is a cooperative effort involving many individuals and agencies. More than 75 scientists and educators have helped to generate the materials, and hundreds of teachers and thousands of students have been involved in the project's nationwide testing program. All of the ISIS endeavors have been supported by generous grants from the National Science Foundation. We hope that ISIS users will conclude that these large investments of time, money, and effort have been worthwhile.

Ernest Burkman

Ernest Burkman
ISIS Project   Tallahassee, Florida

Contents

What's It All About?

You probably won't be an Olympic champion or a professional athlete. But if you keep fit, you'll be able to do the things you enjoy in life.

Keeping fit means more than doing exercises. It means knowing how your heart and other muscles work. It also means knowing how to take care of your muscles, tendons, and joints. And it means getting in shape and staying in shape.

Activity 1
Core Planning

Do Activity 1 first. Then do Activities 2, 3, or 4 (if you plan to do them). After that, Activities 5 through 13 may be done in any order.

In Activities 2, 3, 4, and 5, you will be doing vigorous exercises. If you can't do the exercises for health reasons, check with your teacher.

Activity 2 Page 6

Objective 2-1: Describe how to measure endurance; identify activities that require good endurance.
Sample Question: Which activity does not require as much endurance as the others?
a. basketball
b. golf
c. briskly walking
d. jogging

Objective 2-2: Describe how often (frequency), how much (intensity), and how long (duration) young adults should exercise when trying to improve their endurance.
Sample Question: In terms of heart rate, how intense should exercise be to improve a person's endurance?

Activity 3 Page 13

Objective 3-1: Describe how to measure strength of abdominal muscles; identify activities that require good strength.
Sample Question: Which activities require the most abdominal strength?
a. mountain climbing
b. golf
c. jogging
d. gymnastics

Objective 3-2: Tell why exercising in sets is a good technique to increase strength.
Sample Question: Suppose you alternate exercise with short periods of rest. Why is this a good way to increase strength?

Activity 4 Page 19

Objective 4-1: Describe how to measure flexibility; identify activities that require good flexibility.
Sample Question: Which activities require good flexibility?
a. football
b. bike riding
c. gymnastics
d. jogging

Objective 4-2: Describe the way flexibility varies among people.
Sample Question: The flexibility of most people can be described as
a. excellent.
b. average.
c. poor.

Objective 4-3: Describe how to do stretching exercises properly.
Sample Question: When doing stretching exercises, about how long should you hold a position?

Activity 5 Page 24

REQUIRED ACTIVITY

Be sure to do this activity after you finish Activities 2, 3, and 4. If you don't do Activities 2, 3, or 4, you may do this one anytime.

Activity 6 Page 27

Objective 6-1: Describe the characteristics of a well-conditioned (strong) heart.

Sample Question: Which of the following best describes a strong heart?

a. It beats faster.

b. It can deliver less oxygen.

c. It can deliver more oxygen.

Objective 6-2: Describe what happens to muscles as they get stronger from regular exercise.

Sample Question: What happens to the skeletal muscle fibers as a man becomes stronger?

a. They become more numerous.

b. They get larger.

c. They get longer.

d. All the above are true.

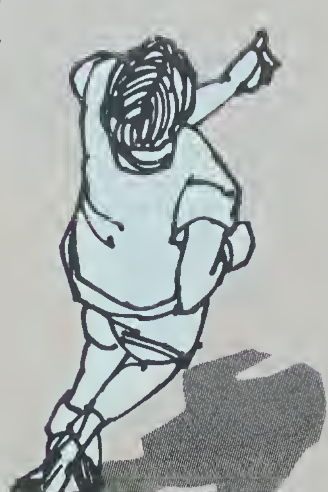
Objective 6-3: Explain why women usually don't develop bulging muscles when they exercise regularly.

Sample Question: Which of the following best explains how exercises affect most women?

a. More muscle fibers develop (form).

b. Muscles get larger.

c. More muscle fibers are used.



Activity 7 Page 31

Objective 7-1: Match the common and scientific names of 20 major bones and describe the role bones play in supporting other body organs.

Sample Question: Match the common and scientific names of the following bones.

Common Name

a. breastbone

b. shoulder blade

c. leg bone

Scientific Name

1. scapula

2. sternum

3. femur

4. humerus

5. ilium

Objective 7-2: Describe how muscles move bones.

Sample Question: What is the minimum number of muscles needed to move a bone in more than one direction?

Activity 8 Page 35

Objective 8-1: Identify by location examples of four major types of human joints and describe the movement that each joint provides.

Sample Question: Match each type of joint with one of its locations in the body.

Type of Joint
a. hinge
b. immovable
c. slightly movable
d. ball-and-socket

Location in Body
1. skull
2. elbow
3. vertebrae
4. hip

Objective 8-2: Describe the role of tendons.

Sample Question: Which statement best describes the role of tendons?

a. Tendons attach muscles to muscles.
b. Tendons attach ligaments to muscles.
c. Tendons attach bones to bones.
d. Tendons attach muscles to bones.

Activity 9 Page 38

Objective 9-1: Describe the causes of sore muscles, muscle pulls, bruises, and the possible cause of muscle cramps, and identify the immediate and long-range treatments for these muscle problems.

Sample Question: Which of the following muscle problems involve torn muscle fibers and broken blood vessels?

a. cramp
b. pull
c. bruise
d. stiffness

Activity 10 Page 44

Objective 10-1: Recognize the symptoms of sprains and dislocations and describe their treatment.

Sample Question: What are two symptoms of a sprain?

Activity 11 Page 48

Objective 11-1: Explain how the heart, lungs, brain, and spinal cord are packaged for protection.

Sample Question: Which of the following structures provide protection for both the brain and the spinal cord?

a. bones
b. membranes
c. fluid
d. fat pads
e. ligaments
f. muscles

Activity 12 Page 51

Objective 12-1: Given statements about exercise, determine whether they are based on factual evidence or on opinions.

Sample Question: For each statement write "fact" or "fable," depending on the truth or falsity of the statement.

a. Athletes need more protein in their diets than nonathletes.
b. Eat a candy bar for quick energy during a game.
c. Muscles turn to fat after you stop exercising.
d. It's good to drink fluids during rest periods while exercising.

Activity 13 Page 54

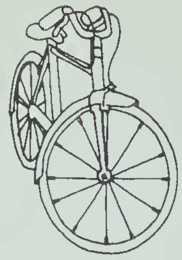
Objective 13-1: Describe how the muscle sensor functions as part of a feedback system.

Sample Question: Where does the nerve message travel first after a muscle sensor is stimulated?

Answers

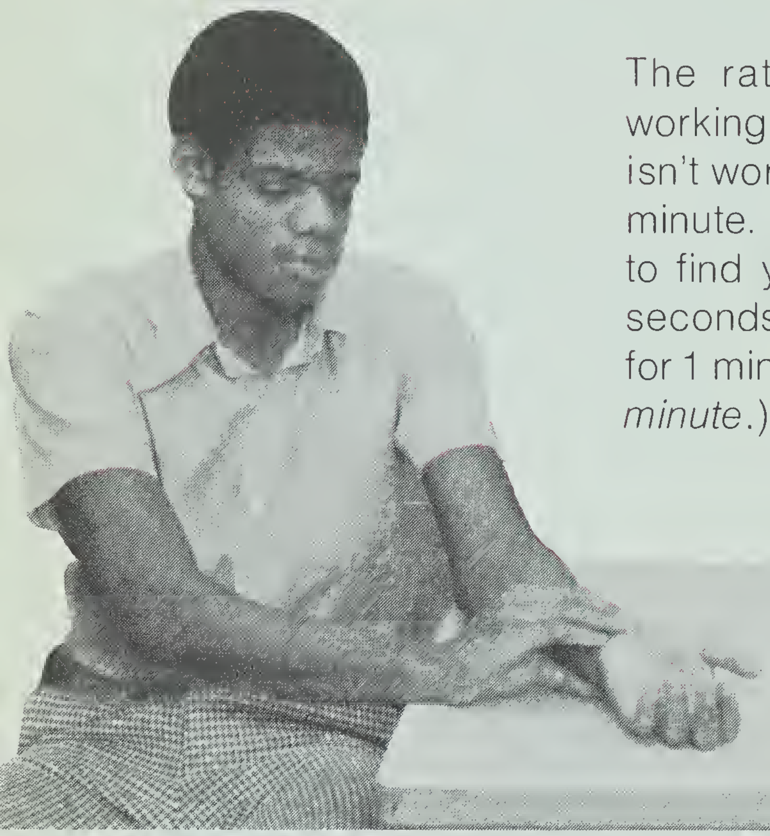
2-1. b **2-2.** 150-175 beats/min. **3-1.** a, d **3-2.** More work is done. **4-1.** a, c **4-2.** b **4-3.** 20-30 seconds **6-1.** c **6-2.** b **6-3.** c **7-1.** a-2, b-1, c-3 **7-2.** two **8-1.** a-2, b-1, c-3, d-4 **8-2.** d **9-1.** b, c **10-1.** pain, swelling **11-1.** a, b, c **12-1.** a, b, c are fables, d is a fact. **13-1.** the spinal cord

ACTIVITY EMPHASIS: What is endurance and what is the effect of frequency, intensity, and duration of exercise on endurance?



Activity 2
Endurance

MATERIALS PER LAB GROUP
See Materials and Equipment, pp. TM 3-4. See also Advance Preparation, p. TM 5.



The rate your heart beats tells you how hard your heart is working. Right now you're probably sitting in a chair. Your heart isn't working too hard. Its rate is probably about 70 or 80 beats per minute. You can find your heart rate by counting your pulse. A way to find your pulse is shown in Figure 2-1. Count the beats for 30 seconds. Then multiply this number by 2 to get the number of beats for 1 minute. (Heart rate is usually given as the number of beats *per minute*.) **Some students may need help in finding their pulse.**

TAKING YOUR PULSE

$$\begin{array}{rl} 38 & \text{beats for 30 seconds} \\ \times\ 2 & \\ \hline 76 & \text{beats for 1 minute (heart rate)} \end{array}$$

Press lightly on the outer side of your upturned wrist. If you can't feel the pulse, move your fingers to a nearby spot. Keep doing this until you can feel the pulse.

Figure 2-1

Practice counting your pulse. You'll have to do it several times during this minicourse. You'll need a watch or clock with a second hand.

- 2-1. What is your heart rate while you're resting?

2-1. Answers will vary, but probably will be between 70 and 80 beats per minute.

Your heart rate increases during exercise. How much it increases depends on the kind of exercise and your *endurance*. Endurance is the heart's ability to withstand stress. If your endurance is good, your heart rate will quickly recover (slow down) after exercise.

• 2-2. A long distance runner needs good endurance. Explain what "good endurance" means.

2-2. It means that the runner's heart can withstand stress. And after a race the runner's heart rate will recover faster than the heart rate of someone whose endurance is poor.

You can find out about your endurance (your *heart's* endurance) by doing the Step Test. You'll need a partner and the following equipment:

sturdy chair or bench, the seat 40 cm from floor
watch or clock with second hand
notebook
Class Rating Chart

The bench or chair must be 40 cm high for validation of results. For directions on preparing the bench, see Advance Preparation, p. TM 5.

The Step Test consists of one exercise that's done over and over for four minutes. The exercise has four positions, shown in Figure 2-2. The signals for the positions are *UP-TWO-DOWN-TWO*. It should take two seconds to do one complete exercise.

The *Class Rating Chart,* supplied separately, is needed for this activity. Be sure to display the chart where students can write on it. (For directions on preparing it, see Advance Preparation for Activities 2, 3, and 4, p. TM 5.)

STEP-TEST EXERCISE

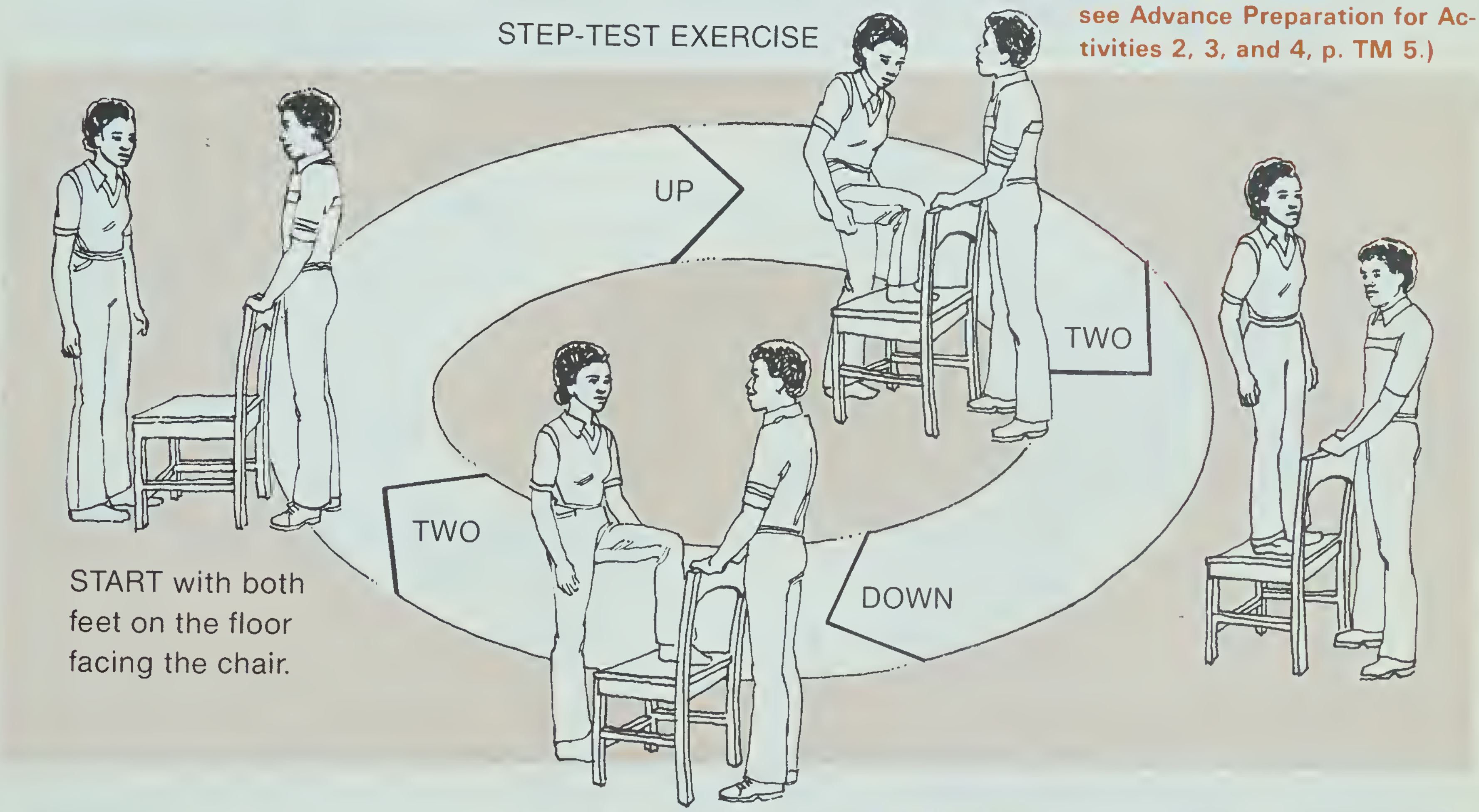


Figure 2-2 Students should take it easy when they practice the step-test exercise so that they won't be too tired for the Step Test.

Your partner is the timekeeper, gives the signal, and holds the chair steady. Before starting the test, your partner should practice saying *UP-TWO-DOWN-TWO* in exactly two seconds. The words must be said at an even pace. They are said again and again for four minutes. It's important that you keep the correct pace — one complete exercise every two seconds. Otherwise, the test will not be an accurate measure of your endurance.

In the planning activity, students are directed to check with their teacher if they feel they cannot do vigorous exercises. Rather than leave it up to students to evaluate their health, you might check with the school nurse or the physical education department to see if any students have a medical problem that would preclude their doing the exercises.

The Step Test is described below. You and your partner should read through the test first, and then begin.

CAUTION **Avoid vigorous exercise right after meals. It may cause stomach discomfort.**

Step Test

A. Do the Step-Test exercise for 4 minutes. (The exercise is shown on page 7.)

B. Rest for 1 minute.

C. Then count your pulse for 30 seconds and record the rate in your notebook.

D. Rest for 30 seconds.

E. Then count your pulse for 30 seconds and record the rate in your notebook.

F. Rest for 30 seconds.

G. Then count your pulse for 30 seconds and record the rate in your notebook.

H. Add the three pulse rates. The sum is your *recovery index* — a measure of how long it takes for you to recover from strenuous exercise. Locate your recovery index in the chart in Figure 2-3.

RATINGS FOR ENDURANCE (STEP TEST)

RECOVERY INDEX	ENDURANCE RATING
199 or more	Poor
171 to 198	Fair
150 to 170	Good
133 to 149	Very Good
132 or less	Excellent

Figure 2-3

• 2-3. What is your endurance rating? **2-3. Answers will vary but most should be either *fair, good, or very good,* and a few should be *poor* or *excellent*.**

Find the Class Rating Chart displayed somewhere in the classroom. Record your rating in the "Endurance" section. In your notebook, record and label your recovery index and endurance rating. You'll need these for Activity 5, the required activity.

• 2-4. If there are many endurance ratings recorded on the Class Rating Chart, name the ratings that appear most often. If there are only a few ratings recorded, name the ratings that you would *expect* to appear most often.

2.4 Fair, good, and very good, with good being the most common rating.

Most people are about average in endurance. They have a rating of good. Only a few people have a rating of poor or excellent. Having good endurance means being able to do a lot without getting too tired. It also means recovering quickly after you finish an activity. Good endurance (at least) is needed for physical activities that have a lot of action. Some of these activities are shown in Figure 2-4. If you have very good or excellent endurance, you won't get too tired doing some of these activities.

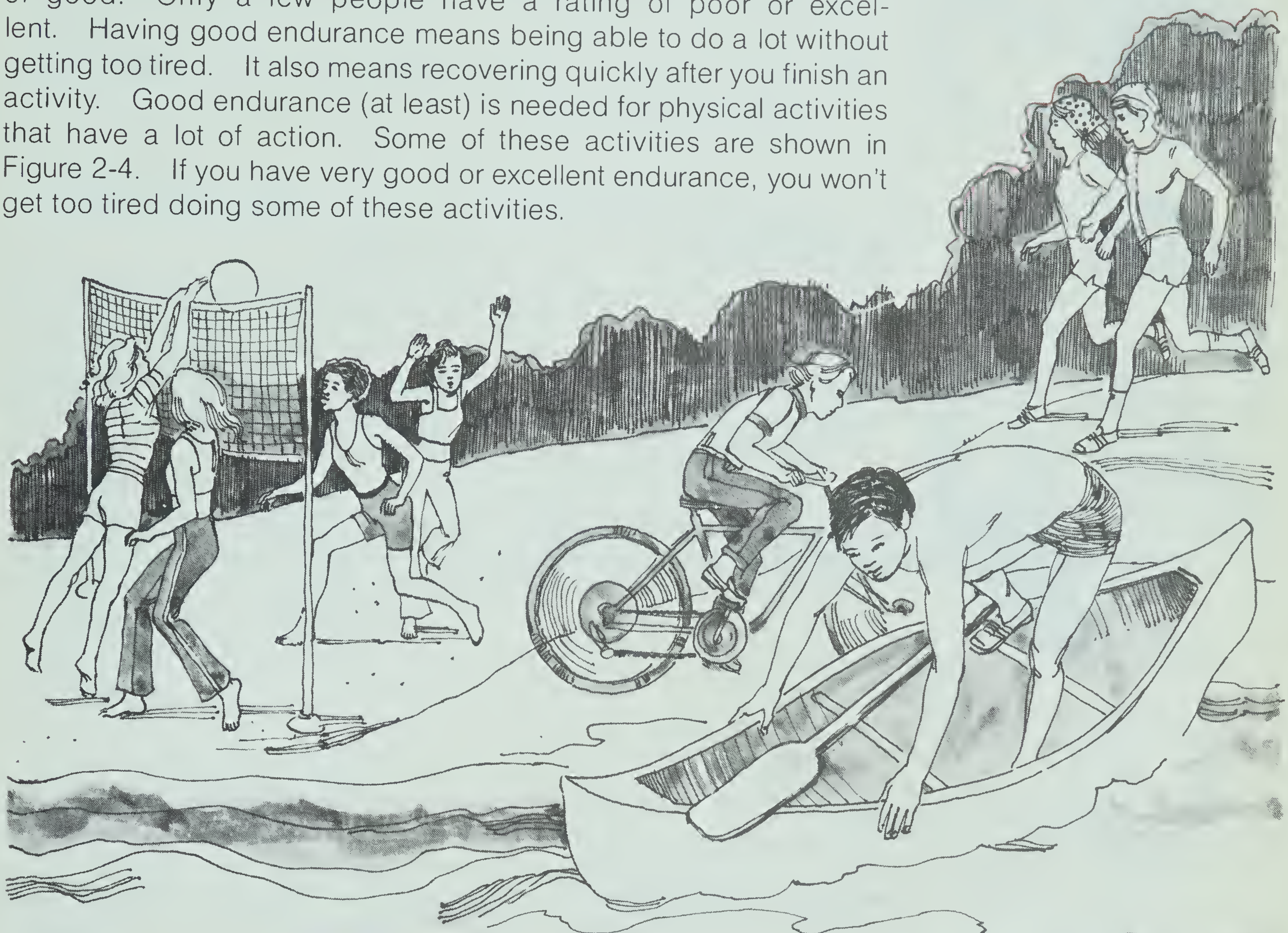


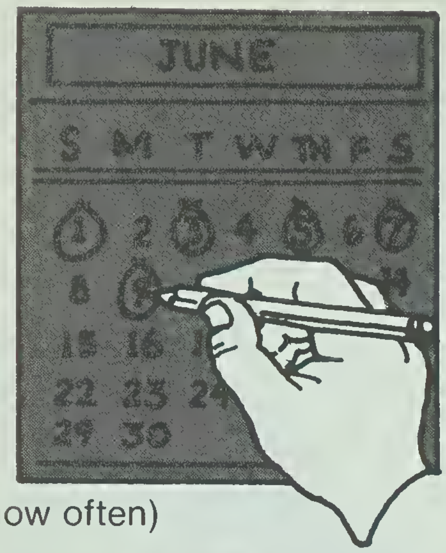
Figure 2-4 **2.5 Any five of these answers:** ***volleyball, bicycling, jogging, canoeing, swimming, basketball, square dancing, running, tennis, handball, badminton, etc.***

★ **2-5. List five physical activities that require good endurance.**

★ **2-6. Describe an accepted and often used method for measuring a person's endurance.**

There are many different exercises that you can do to improve your endurance. These exercises strengthen your heart — the most important organ in determining endurance. To safely strengthen your heart, an exercise program should be planned according to the *frequency* (how often), *intensity* (how hard), and *duration* (how long) of the exercises.

2-6. See page 8 for a description of the Step Test. Students may know of other methods related to jogging and running like the Cooper's Endurance Test or the Tread-Mill Test but the Step Test is most often used.



(how often)

FREQUENCY

The frequency of exercise should be on a regular basis. Exercising regularly is called *training*. A good plan is to train every other day. Results have shown that exercising three to four days a week is ideal. You'll strengthen your heart quickly and get a chance to rest during the "off" days.

- 2-7. Why is it recommended that you train only 3 or 4 days a week rather than every day?

2-7. On the days that you don't train, you get a chance to rest.

(how hard)

INTENSITY

The intensity of exercise is determined by your heart rate. In order to strengthen your heart, stress must be exerted on it. If you are between the ages of 15 and 25, your heart rate should be about 150 to 175 beats per minute while exercising. If the rate is less than 150, there may not be enough stress on your heart. It will not be efficiently strengthened. If the rate is more than 175, there is too much stress. You'll probably tire too quickly for the exercise to do any good. To find the intensity of exercising that's right for you, count your pulse as soon as you stop exercising.

(how long)

DURATION

The duration of exercise should be at least 15 minutes. But the exercise does not have to be at the same intensity for the entire time. A program that alternates exercise and rest can be followed. This is called an *interval exercise program*. It gives your heart and other muscles a chance to recover. In any case, the time actually spent exercising should be about 15 minutes.

★ **2-8. Suppose you wanted to plan an exercise program to get in shape. There are three factors for improving endurance that you should consider. Describe the factors.**

2-8. Frequency (about every other day), intensity (so that heart rate is between 150-175 beats/min), and duration (at least 15 minutes of actual exercise).

Now try exercising in an interval exercise program. The program described here alternates a rope-jumping exercise with rest periods. After each exercise and each rest period, a pulse count is taken. Remember — to count pulse, count the beats for 30 seconds and then multiply the number by 2. This will give you the number of beats for 1 minute.

You'll need an entire class period to do the rope-jumping program. If you don't have time to do it now, go to another activity. Come back to this one as soon as you can. You'll need these materials:

Some students may not know how to jump rope. You might ask one or two students to demonstrate.

jump rope
watch or clock with second hand
notebook
graph paper

CAUTION **Avoid vigorous exercise right after meals. It may cause stomach discomfort.**

First draw a chart in your notebook like the one in Figure 2-5. Then do Steps A through E, described below.

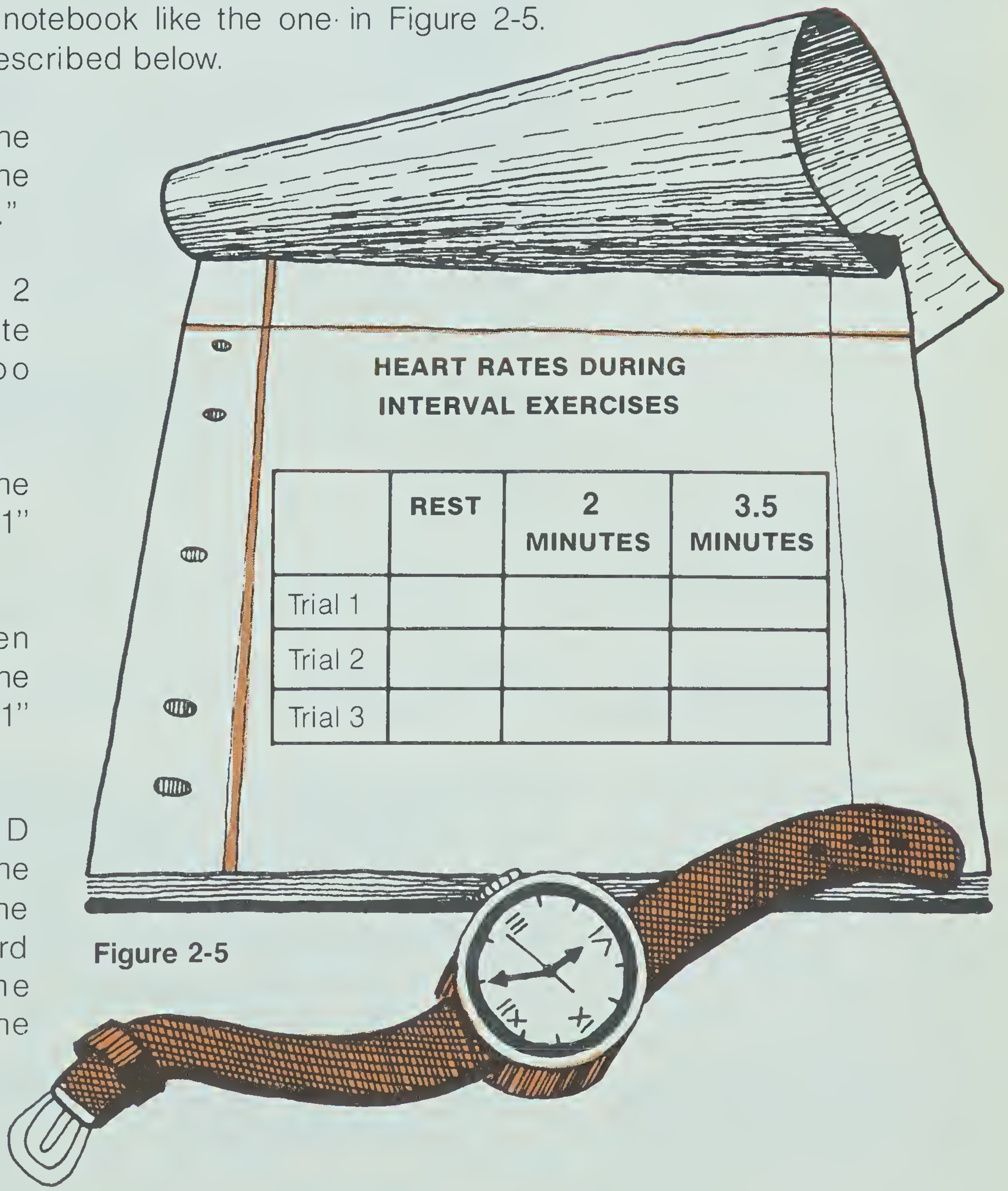
A. Take your pulse. Write the result in your chart in the box for "Trial 1" and "Rest."

B. Jump rope for exactly 2 minutes. Jump at a rate that won't tire you too quickly.

C. Take your pulse. Write the result in the box for "Trial 1" and "2 minutes"

D. Rest for 1 minute. Then count your pulse. Write the result in the box for "Trial 1" and "3.5 minutes."

E. Repeat Steps A through D two more times. (Call the second time *Trial 2*, and the third time *Trial 3*.) Record your heart rates in the appropriate boxes in the chart.



	REST	2 MINUTES	3.5 MINUTES
Trial 1			
Trial 2			
Trial 3			

Figure 2-5

On a piece of graph paper, set up a grid like the one shown in Figure 2-6. Then plot the points on your graph for the heart rates recorded in your chart. Connect each set of points with a line. The "0 minutes" in the grid corresponds to "Rest" in the chart. There should be three curves in your graph. (If you need help, do *Resource Unit 4.*) Tape your graph in your notebook.

The graph will show how your heart reacted to exercise and rest. The peaks in the curves show that your heart rate speeded up during exercise; the valleys show that it slowed down during rest.

Look again at Figure 2-6. Notice that the desired range during exercise is from 150 to 175 beats per minute.

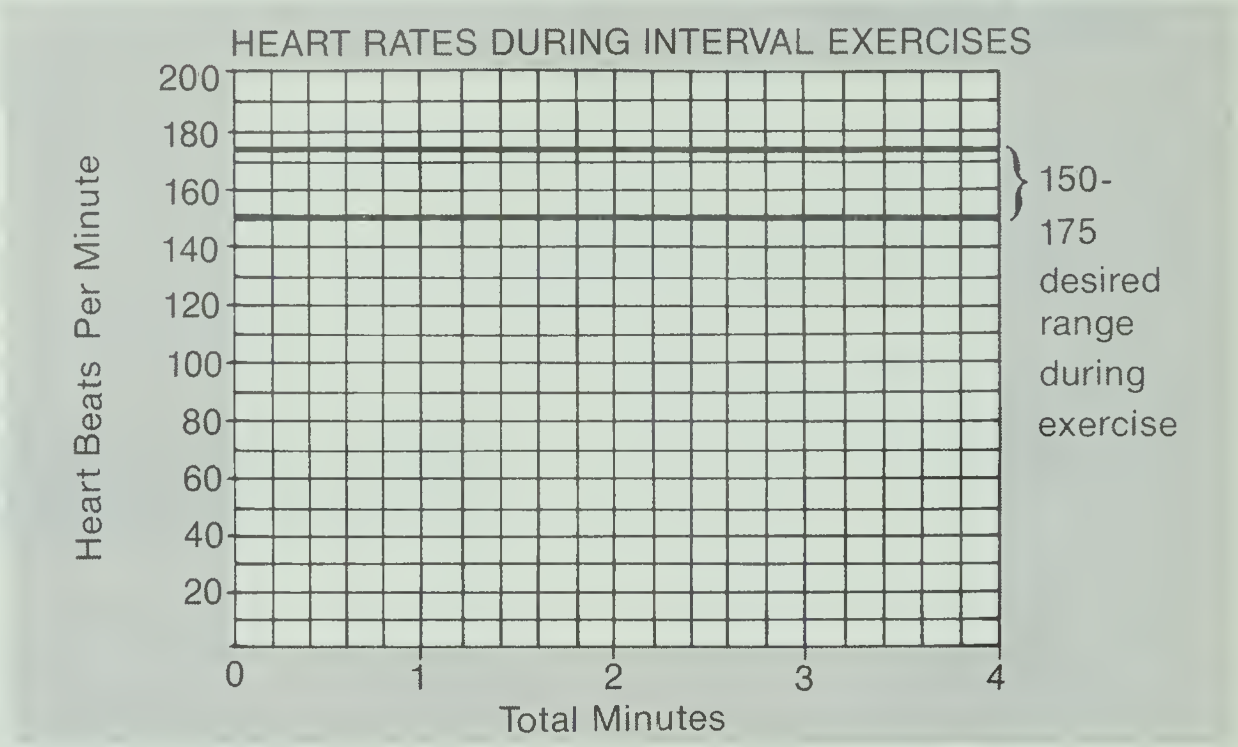


Figure 2-6

- 2-9. What was your fastest heart rate during the exercise periods?

2-9. Answers will vary, but should not be in excess of 175 beats/min.

- 2-10. What was your slowest heart rate during the exercise periods?

2-10. Answers will vary, but should not be below 150 beats/min.

- 2-11. Suppose your heart rate remained more than 175 beats per minute during exercise. What could you do to keep the rate from going so high?

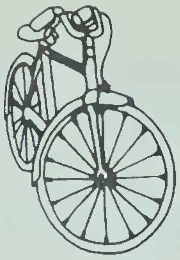
2-11. Jump at a slower pace.

- 2-12. Suppose your heart rate remained less than 150 beats per minute during exercise. What could you do to make the rate go higher?

2-12. Jump at a faster pace.

- 2-13. What are some other activities that you could do to improve your endurance?

2-13. Running, swimming, bicycling, playing handball or soccer, etc.



Activity 3
Strength

MATERIALS PER LAB GROUP
See Materials and Equipment, pp. TM 3-4.
See also Advance Preparation, p. TM 5.

ACTIVITY EMPHASIS: How to use exercise sets to increase muscular strength.

Physical activities are easy to do if you have strong muscles that don't tire quickly. Strong muscles are needed for activities like the ones shown in Figure 3-1.

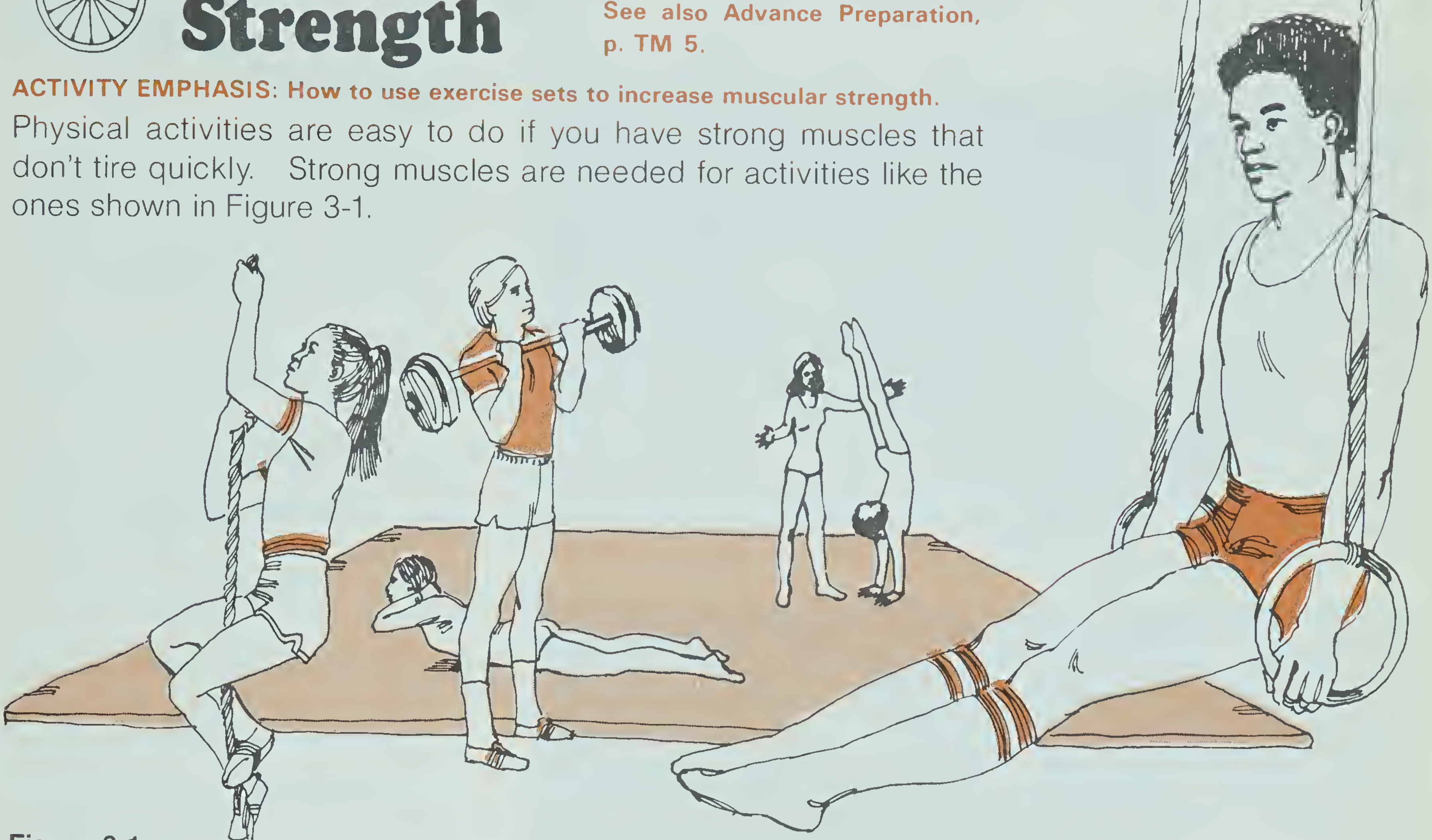


Figure 3-1

If you have weak muscles, you probably have trouble exerting force on objects. You may not be able to kick, throw, hit, or run too well.

★ **3-1. Name three activities that require strong muscles.**

3-1. Any three of these answers: *weight lifting, gymnastics, calisthenics, rope climbing, mountain climbing, skiing, etc.*

• 3-2. How do strong muscles help you to do well in physical activities?

3-2. When you have strong muscles, you can exert enough force to kick, throw, hit, and run well.

In the planning activity, students are directed to check with their teacher if they feel they cannot do vigorous exercises. Rather than leave it up to students to evaluate their health, you might check with the school nurse or the physical education department to see if any students have a medical problem that would preclude their doing the exercises.

Do you have good abdominal muscles (sometimes called stomach muscles)? Do the Sit-Ups Test to find out. You'll need a partner for the test. Your partner is the timekeeper, tells you when to start and stop, and holds your feet on the floor. You'll also need the following items:

rug or small mat to lie on
watch or clock with second hand
notebook
Class Rating Chart

The *Class Rating Chart,* supplied separately, is needed for this activity. Be sure to display the chart where students can write on it. (For directions on preparing it, see Advance Preparation for Activities 2, 3, and 4, p. TM 5).

CAUTION **Avoid vigorous exercise right after meals. It may cause stomach discomfort.**

Sit-Ups Test

A. Lie on your back. Put your feet flat on the floor and your knees at a 90° angle. Your partner holds your feet.

B. When your partner tells you to start, sit up and touch the outside of your knees with your elbows. Then return to the position described in Step A. You have completed one sit-up.

C. Do as many sit-ups as you can in 2 minutes. Count out loud each time you sit up. Your partner must tell you to stop after exactly 2 minutes.

3-3. Answers will vary.

• 3-3. How many sit-ups did you do in 2 minutes?

Look at the charts in Figure 3-2. Find your rating for abdominal muscle strength and endurance. If you're female, use your weight to the nearest 10 pounds. If you're male, use your age to the nearest one-half year. Because of growth-spurt differences, females are listed by weight and males by age.

Look at the numbers listed in the columns labeled *Good*. Consider the "middle" number (or numbers) to be the average for that weight or age. Suppose you're a 143-pound girl who rated *good*. The average number of sit-ups that you should be able to do is 45 or 46. (In the chart, the range listed is 40-51 or 40, 41, 42, 43, 44, **45, 46,** 47, 48, 49, 50, 51. The "middle" numbers are 45 and 46.)

RATINGS FOR STRENGTH (SIT-UPS TEST)

ABDOMINAL MUSCLE STRENGTH AND ENDURANCE—FEMALE					
Weight (lbs.)	Poor	Fair	Good	Very Good	Excellent
100	0-34	35-46	47-58	59-70	71+
110	0-32	33-44	45-56	57-68	69+
120	0-31	32-43	44-55	56-67	68+
130	0-29	30-41	42-53	54-65	66+
140	0-27	28-39	40-51	52-63	64+
150	0-25	26-37	38-49	50-61	62+
160	0-24	25-36	37-48	49-60	61+
170	0-22	23-34	35-46	47-58	59+
180	0-20	21-32	33-44	45-56	57+

RATINGS FOR STRENGTH (SIT-UPS TEST)

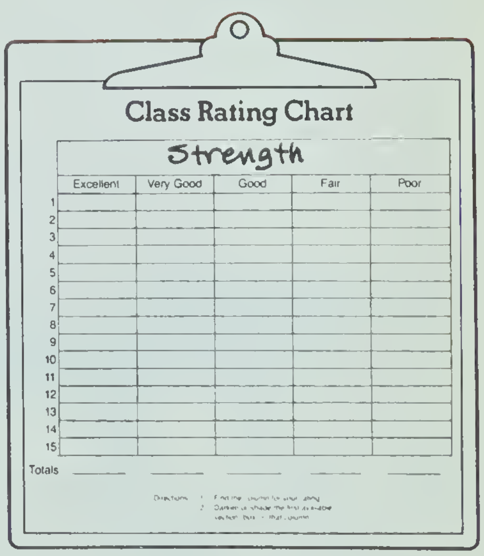
ABDOMINAL MUSCLE STRENGTH AND ENDURANCE—MALE					
Age (Years)	Poor	Fair	Good	Very Good	Excellent
14	0-39	40-57	58-75	76-92	93+
14½	0-40	41-58	59-76	77-94	95+
15	0-41	42-59	60-77	78-95	96+
15½	0-42	43-60	61-78	79-96	97+
16	0-43	44-61	62-79	80-97	98+
16½	0-44	45-62	63-80	81-98	99+
17	0-45	46-63	64-81	82-99	100+
17½	0-46	47-64	65-82	83-100	101+
18	0-47	48-65	66-82	83-101	102+

Figure 3-2

• 3-4. What is your rating for abdominal muscle strength and endurance?

3-4. Answers will vary but most should be either *fair, good, or very good,* and a few should be *poor* or *excellent.*

Find the Class Rating Chart. It's probably displayed somewhere in the classroom. Record your rating in the section labeled "Strength." In your notebook, record and label your rating for abdominal strength and the number of sit-ups that you did. You'll need these for Activity 5, the required activity.

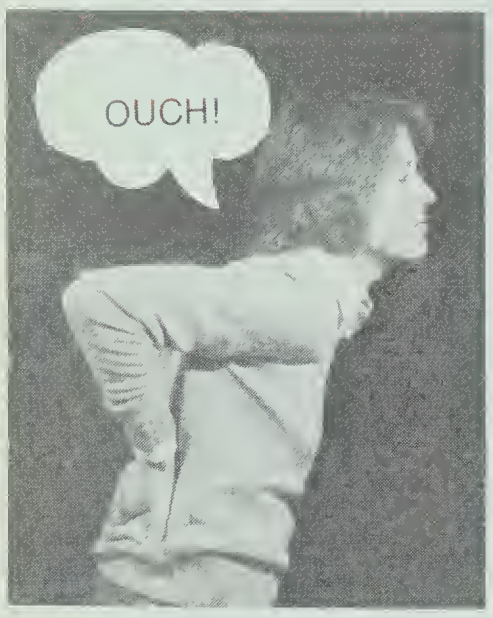


• 3-5. Suppose you are a 16 year-old male. You do 50 sit-ups in 2 minutes. What is your rating for abdominal strength and endurance? (See Figure 3-2.) **3-5. Fair.**

3-6. Fair, good, and very good, with good being the most common rating.

- 3-6. Look at the Class Rating Chart. If there are many ratings recorded for strength, name those that appear most often. If there are only a few ratings recorded, name those that you would *expect* to appear most often.

Most scores for a physical ability are in the middle — most people are average. But there are usually some extreme scores too — a few people are excellent or poor.



Some muscles are weaker than others because they don't get used often. Did you ever see someone with a big sagging "stomach"? Usually the sagging is caused by weak abdominal muscles. These muscles can't hold in the "stomach," so it sags.

- 3-7. Why do abdominal muscles get weak?
  3-7. Because they don't get used often enough.

★ **3-8 Describe an accepted method for measuring the strength of abdominal muscles.**
3-8. See page 14 for a description of the Sit-Ups Test.

Do you have weak back muscles? Perhaps you walk enough every day to exercise your legs. But you probably don't exercise your back or abdominal muscles often enough. You can strengthen weak muscles by doing simple exercises. Some exercises are shown in Figure 3-3.

Figure 3-3

3-9. a. arm-shoulder b. abdominal c. back d. arm-shoulder e. neck f. leg

- 3-9. For each exercise shown in Figure 3-3, identify the muscles that are being strengthened.

When you plan an exercise program, you must consider the *frequency* (how often), *duration* (how long), and *intensity* (how hard) of the exercises. The frequency of exercise should be often — every other day. The duration should be at least 15 minutes. And the exercises should be intense enough to do some good. Doing a few calisthenics or lifting light weights won't increase your strength very much. Your muscles need stress — they must work harder than usual.

• 3-10. There are certain exercise requirements in an exercise program. Match each requirement with its description.

Requirement	Description
a. frequency	1. Exercise often.
b. duration	2. Work hard while exercising.
c. intensity	3. Exercise for at least 15 minutes.

3-10. a-1, b-3, c-2

An exercise program that alternates exercise and rest is good for strengthening muscles. This type of program is called an *interval exercise program*. It is made up of exercise sets. For each exercise set, you do one exercise over and over (10 to 15 times), then you rest for a period of time. Usually three exercise sets are done during the exercise period.

As your muscles work, they use stored energy and produce some acid waste products. If you work your muscles too long without resting, most of the stored energy is used up and there's a buildup of acid wastes. As a result, you get very tired. In an interval exercise program, muscles get a chance to rebuild energy and to get rid of the acid wastes. This is done during the rest periods. As a result, you don't tire quickly and you can exercise longer. You do more total work and increase your strength faster.

No attempt was made to explain why the buildup of wastes causes fatigue. If asked about this, it may suffice to say that the accumulation of metabolic wastes, such as lactic acid, causes the muscle to lose its ability to produce enough energy to respond to the impulses of the nerves.

An interval exercise program that you'll be doing requires that you do push-ups. Figure 3-4 shows two methods for doing push-ups. These methods are different because males and females have different muscle structures and different amounts of strength. Method A is usually done by females and Method B by males.

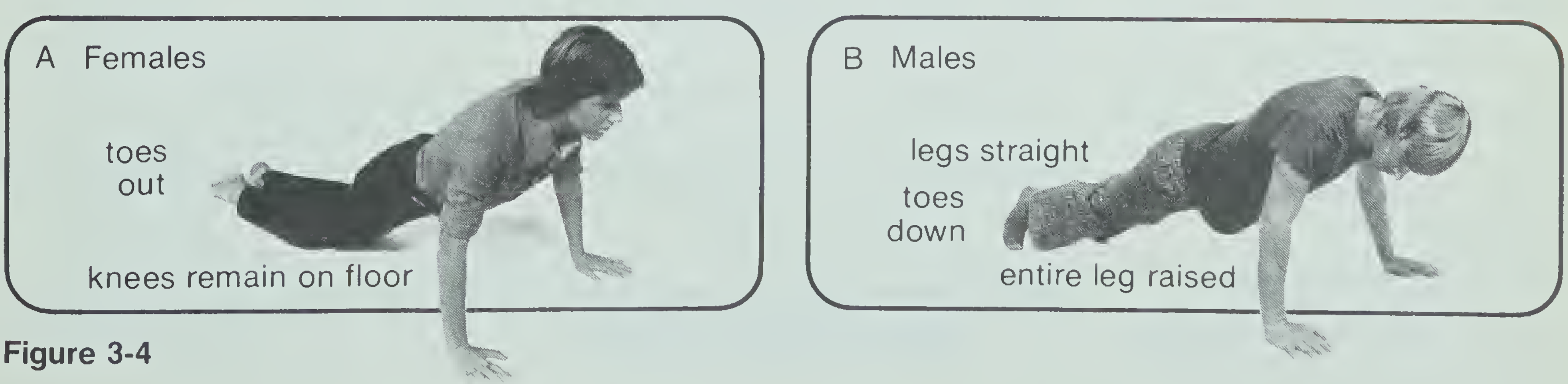


Figure 3-4

The interval exercise program will take about 30 minutes to do. If you don't have enough time, go to another activity. Come back to this one as soon as you can. You'll need a rug or small mat to exercise on. Read through the directions in Figure 3-5 first, then begin.

CAUTION **Avoid vigorous exercise right after meals. It may cause stomach discomfort.**

It's important to note that students need a rest period of 15-20 minutes between push-up trials.

A. *Nonstop Push-Ups*
Do as many push-ups as you can without stopping to rest. Count how many you do. When you can't do any more, answer Question 3-11.

B. Rest your arms for 15-20 minutes. Then come back here and do the push-ups in sets.

C. *Push-ups in Sets*
Do one-half the number of push-ups you gave as your answer to Question 3-11. Then rest for 3 minutes. Do this a total of 3 times.

Figure 3-5

- 3-11. How many nonstop push-ups did you do?

3-11. Answers will vary.

- 3-12. How many push-ups did you do in all three sets?

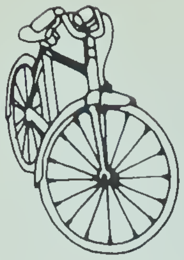
3-12. Answers will vary.

- 3-13. Why was it easier to do more push-ups in sets than by the nonstop method?

3-13. Your body gets a chance to rest between sets.

★ **3-14 Explain how an interval exercise program (exercising in sets) increases strength.**

3-14. You can do more total work before you get tired, thus working your muscles more to strengthen them.



ACTIVITY EMPHASIS: How to measure flexibility and a description of various exercises that improve muscular flexibility.

Activity 4
Flexibility

MATERIALS PER LAB GROUP
See Materials and Equipment, pp. TM 3-4.
See also Advance Preparation, p. TM 6.

The *Class Rating Chart*, supplied separately, is needed for this activity. Be sure to display the chart where students can write on it. (For directions on preparing it, see Advance Preparation for Activities 2, 3, and 4, p. TM 5.)

Good flexibility is important — it allows you to move easier and it decreases the chances of injury. With good flexibility, you can hit a tennis ball that otherwise might be out of reach, and you can avoid pulling a muscle when you run to first base. Figure 4-1 shows some activities that require good flexibility.

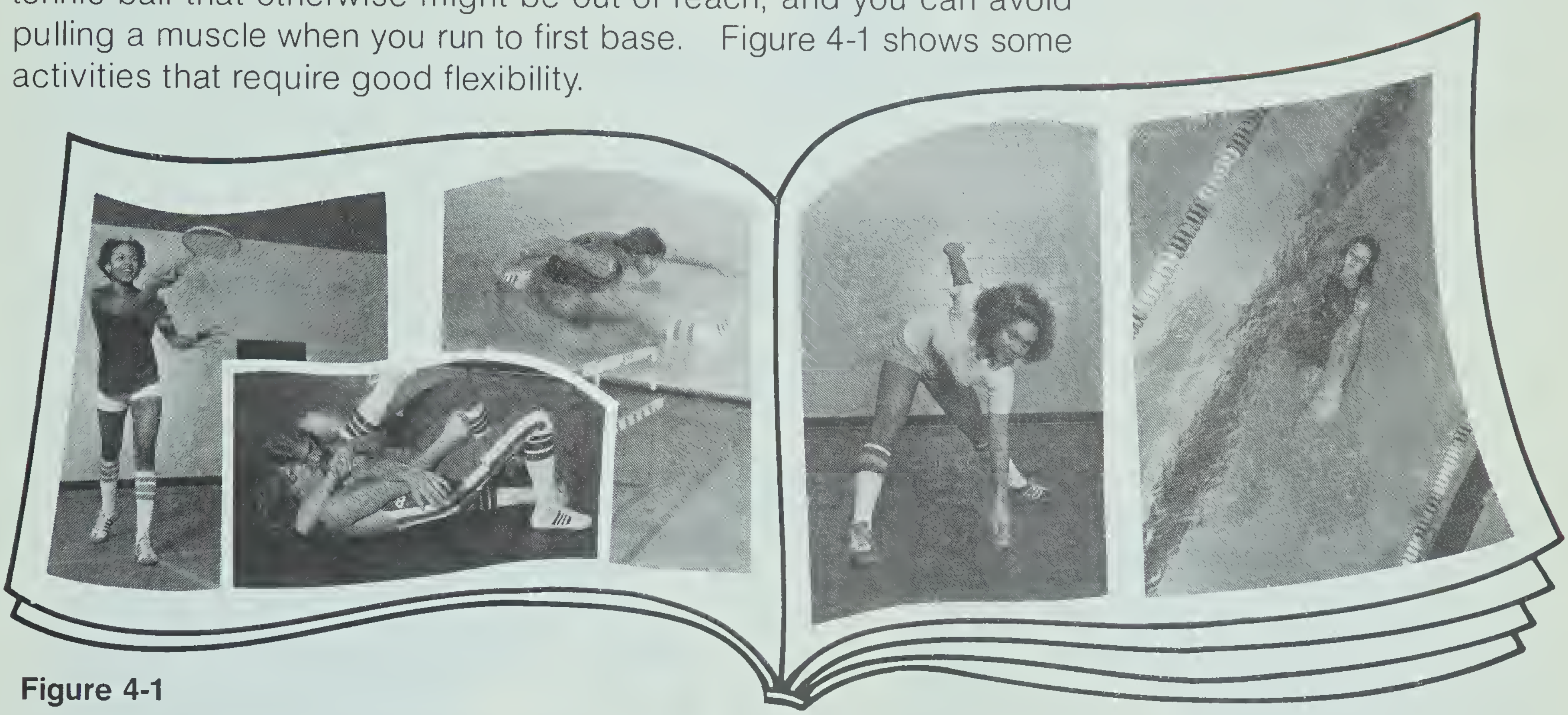


Figure 4-1

★ **4-1. List four physical activities that require good flexibility.**

4-1. Any four of these answers: *calisthenics, gymnastics, wrestling, tennis, judo, etc.*

To get a rough idea of how flexible your body is, do the Toe-Touch Test. You'll need two partners. Partner 1 holds the chair steady. Partner 2 reads the measurements and makes sure you don't fall. You'll also need the following equipment:

flexibility measuring stick
sturdy chair or bench, the seat 40 cm from the floor
tape
notebook
Class Rating Chart

The bench or chair must be 40 cm high for validation of results. For directions on preparing the bench, see Advance Preparation for Activity 2, p. TM 5.

You'll have to find the average of your test results. Can you find the average of 8 and 14? If not, do *Resource Unit 1*. (The average of 8 and 14 is 11.)

Draw a chart like the one in Figure 4-2. You'll need it for recording your test results. You and your partners should read through the test first, then begin.

TOE-TOUCH TEST

TRIAL	SCORE
1	
2	
3	
Average	

Figure 4-2

In the planning activity, students are directed to check with their teacher if they feel they cannot do vigorous exercises. Rather than leave it up to students to evaluate their health, you might check with the school nurse or the physical education department to see if any students have a medical problem that would preclude their doing the exercises.

Students must stretch slowly!

Toe-Touch Test

A. Tape the flexibility measuring stick to the chair. The "0" on the stick should be even with the top edge of the chair seat.

B. Remove your shoes. Climb onto the chair as Partner 1 holds it steady. Your toes should be lined up with the front edge of the chair just touching the measuring stick.

C. Keep your knees straight and slowly bend down. The fingers on both of your hands should be even with each other. Partner 2 makes sure that you don't fall. Do not "bounce" to try to get your hands lower.

D. Partner 2 reads the measuring stick at the lowest point that you reach, and records the measurement (your "score") for *Trial 1* in your chart.

E. Repeat Steps C and D two more times. The measurements should be recorded for *Trial 2* and *Trial 3* in your chart.

F. Get off the chair. Your partners may leave. Find the average for your scores and record it in the chart.

Look at the table in Figure 4-3. Find your rating for flexibility. A score of plus five (+5) is considered about average for females. A score of plus two (+2) is about average for males. Both of these scores have a rating of "good."

RATINGS FOR FLEXIBILITY (TOE-TOUCH TEST)

RATING	FEMALE	MALE
Excellent	+26 or more	+24 or more
Very Good	+19 to +25	+17 to +23
Good	− 8 to +18	−12 to +16
Fair	−15 to − 9	−19 to −13
Poor	−16 or less	−20 or less

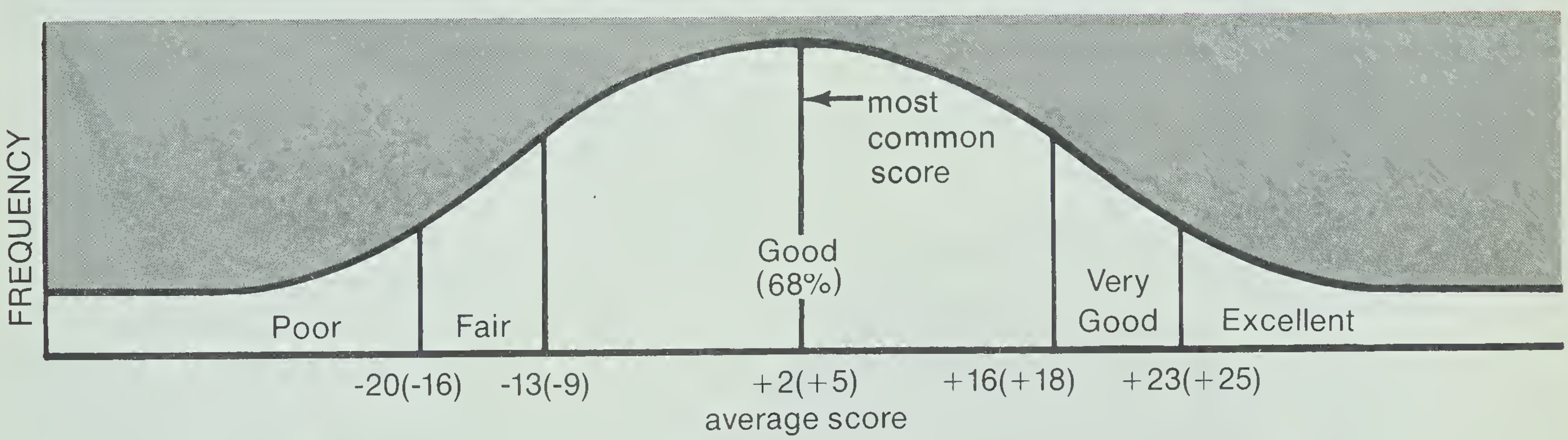
Figure 4-3

★ **4-2. Describe how to determine your rating for flexibility.**

4-2. See page 20 for a description of the Toe-Touch Test and Figure 4-3 for ratings.

In your notebook, record and label your average score and rating. You'll need these for Required Activity 5.

About 68% of the people who take the Toe-Touch Test have a rating of good. A large number of flexibility test scores are graphed in Figure 4-4. Most of the scores are "bunched" in the middle of the graph. The bunched scores have a rating of good. Good flexibility is average for the group. If you have trouble reading the graph, do *Resource Unit 2.*



Flexibility Test Scores for Large Sample (Female test scores in parenthesis)

Figure 4-4

★ **4-3. Suppose you tested 200 people for flexibility. Predict how this trait would vary among the group.**

4-3. Most of the people would be about average; some would be better, some worse.

Physical traits differ among people. If a large number of people were tested for a physical trait, some ratings would be poor and excellent, but most would be fair, good, and very good. If this is the first time you've run into the idea of normal curves, don't worry if the meaning isn't completely clear. You'll see normal curves again in other minicourses. However, if you've seen them before and you still feel uneasy about them, you may want to look at *Resource Unit 19*. It describes normal curves in more detail.

Find the Class Rating Chart displayed somewhere in the classroom. Record your flexibility rating in the section labeled "Flexibility."

4-4. Fair, good, and very good, with good being the most common rating.

• 4-4. Look at the Class Rating Chart. If there are many ratings recorded for flexibility, name those that appear most often. If there are only a few ratings recorded, name those that you would *expect* to appear most often.

4-5. Flexibility is a physical trait, and physical traits vary among people.

• 4-5. Why doesn't everyone have the same flexibility rating?

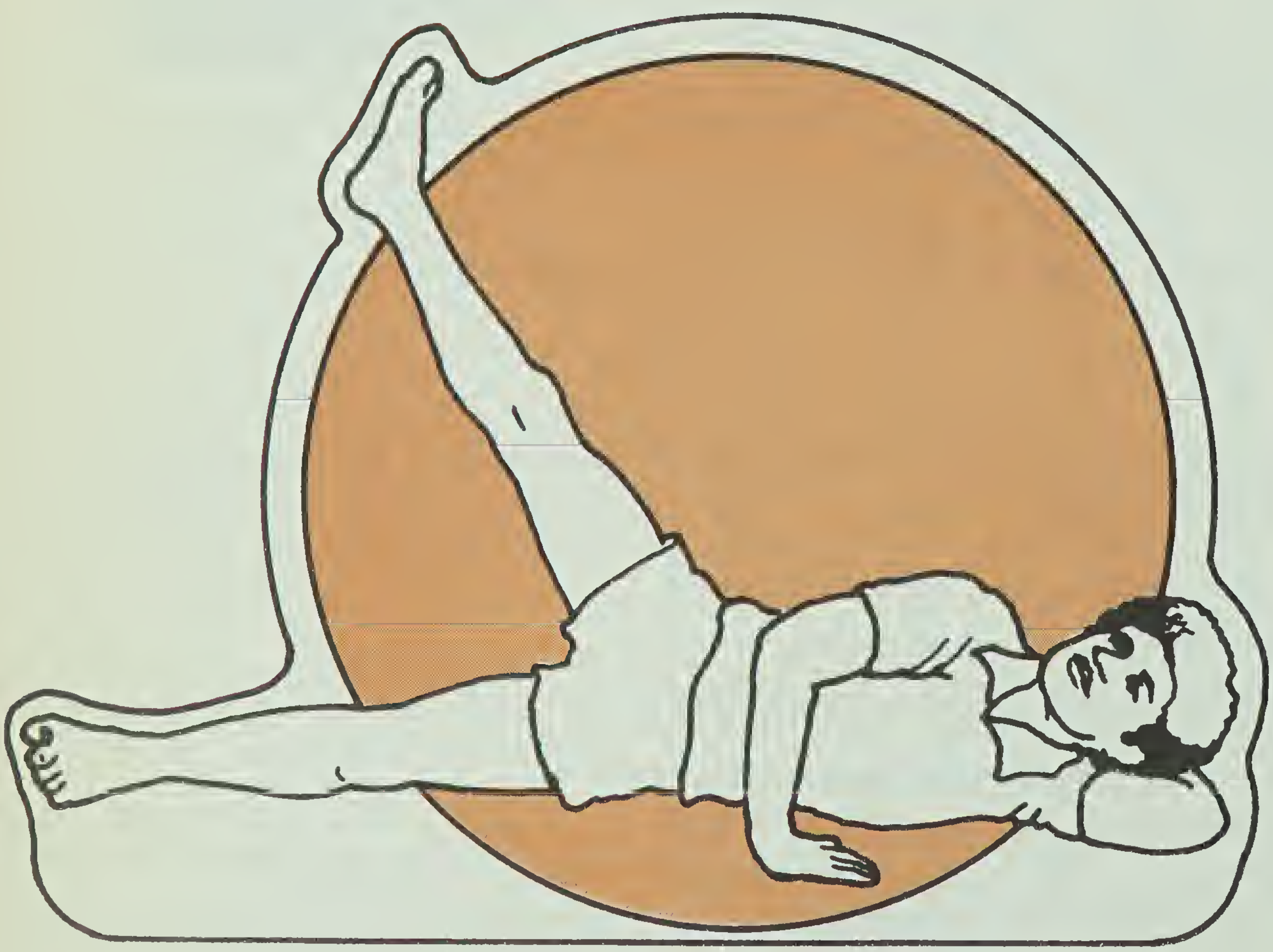
The exercises shown below and on page 23 will help you improve your flexibility. These exercises make you stretch. When you hold a stretched position, you apply a stretching force to your muscles. Be careful not to overstretch and damage muscle fibers. Stretch slowly until you feel a very slight pain in the muscle being stretched. Hold that position for 20 to 30 seconds. Don't try to stretch any further.

You might be tempted to "bounce" instead of stretching slowly. No matter how great the temptation is, *don't bounce!*

4-6. Bouncing could make you overstretch and damage muscle fibers, thus causing soreness.

★ 4-6. Explain why "bouncing" is not recommended when you stretch.

Decide which of your muscles need greater flexibility. Then do the appropriate exercises described below. Exercise regularly.



SIDE LEG RAISE
(muscles on inside of leg)

A. Lie on your side. Rest your head on your lower arm and support your body as shown. Rest one leg on the other.

B. Raise your top leg vertically. Hold the position for 20 to 30 seconds. Return to the starting position. Repeat until you've raised your leg 5 times in all.

C. Turn over and lie on your other side. Do the leg raise 5 times.

LEG STRETCHER
(muscles in upper leg)

A. Sit with your legs stretched out in front of you. Bend at the waist and reach for your toes.

B. Stretch as far as you can. Keep your knees straight. Hold that position for 20 to 30 seconds. Return to the starting position. Do this exercise 5 times.

SHOULDER STRETCH
(muscles in shoulder)

A. Extend your arms over your head, hands together, palms forward.

B. Standing up straight, force your arms backward until you feel a slight pain. Hold that position for 20 to 30 seconds, then relax. Repeat until you've done the exercise 5 times in all.

BODY BENDER
(muscles in the torso)

A. Stand up straight with your feet about 60 cm (about 2 feet) apart.

B. Bend sideways as far as possible. Don't turn your torso. Hold for 20 to 30 seconds, then relax. Repeat, bending to the other side. Continue this procedure until you've done the exercise 5 times on each side.

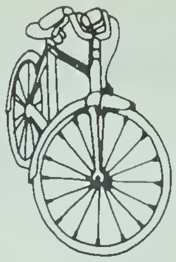
• 4-7. What happens to your muscles as you "hold" the positions in stretching exercises?

4-7. Your muscles are being stretched, making them more flexible.

ACTIVITY EMPHASIS: A summary of the physical traits tested in Activities 2, 3, and 4; and participation in a planned 10-day exercise program to compare the test ratings before and after the program.

MATERIALS PER LAB GROUP
None.

In the planning activity, students are directed to check with their teacher if they feel they cannot do vigorous exercises. Rather than leave it up to students to evaluate their health, you might check with the school nurse or the physical education department to see if any students have a medical problem that would preclude their doing the exercises.



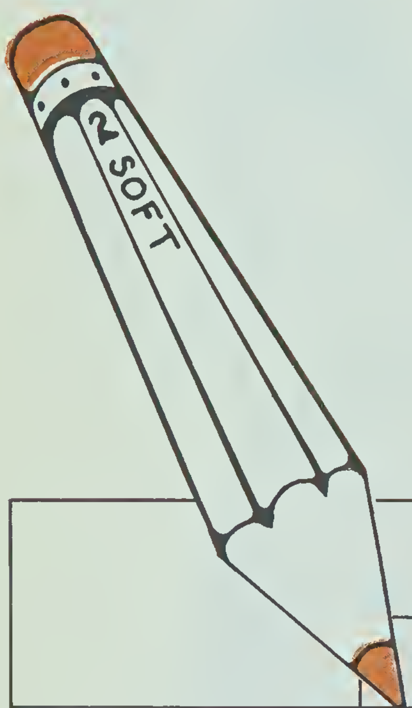
Activity 5
Putting It All Together

In this activity, you'll find out more about yourself, how you compare with other people, and how humans vary in physical traits.

Look at Figure 5-1. It's a summary chart for the physical traits tested in Activities 2, 3, and 4. Draw a similar chart and fill out the row labeled *Before Program*. If you did Activities 2, 3, and 4, the information for the chart should be in your notebook. If you skipped Activity 2, 3, or 4, follow one of the two procedures described below.

Procedure 1: Take the test for the activity. Turn to the appropriate activity and follow the directions for the test. Then record the results in your summary chart in the row labeled *Before Program*.

Procedure 2: Rate yourself for endurance, abdominal strength, or flexibility. Use the ratings *excellent, very good, good, fair,* and *poor.* Then, using the lowest number listed for your rating, find the following: recovery index (Figure 2-3), number of sit-ups (Figure 3-2), and toe-touch score (Figure 4-3). For example, if you rated yourself *fair* in endurance, use 171 for your recovery index (Figure 2-3). If you're male and rated yourself *fair* in flexibility, use −19 for your toe-touch score (Figure 4-3). Record the test results in your summary chart in the row labeled *Before Program*.



SUMMARY CHART

	ENDURANCE (ACTIVITY 2)		ABDOMINAL STRENGTH (ACTIVITY 3)		FLEXIBILITY (ACTIVITY 4)	
	Rating	Recovery Index	Rating	Number of sit-ups	Rating	Toe-Touch Test score
Before Program						
After Program						

Figure 5-1

5-1. Most answers will be *no*.

• 5-1. What is your rating for each physical trait? Did you rate the same in all three traits?

If your rating varies from trait to trait, don't worry. Each activity or exercise you do develops your body in a slightly different way. A person with *excellent* endurance, *good* strength, and *poor* flexibility might not run fast but might be a good gymnast.

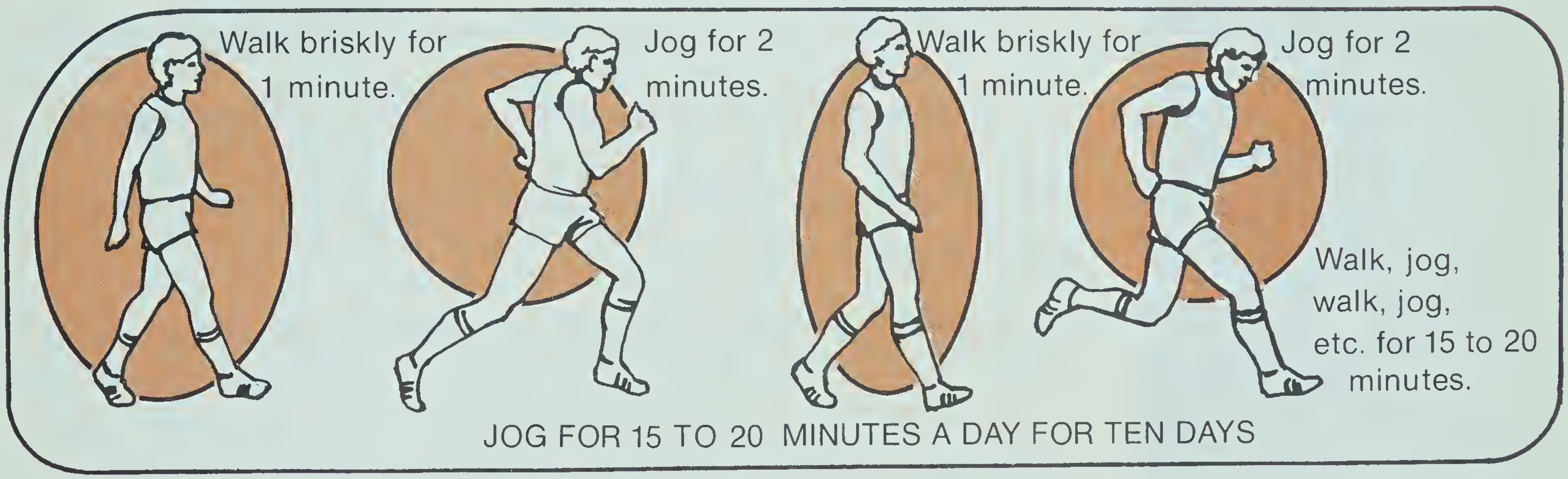
Each person inherits physical traits different from those of any other person. And each person has habits different from those of any other person. It's no wonder we have physical differences.

- 5-2. Compare your ratings with those of another student. List the traits for which your ratings were the same. List those for which your ratings were different.

5-2. Answers will vary.

If your rating is *fair* or *poor* for any trait, you're not physically fit. You need to exercise. Plan a ten-day exercise program. The program should consist of one or more of the following physical activities, depending on which trait you need to improve. You might want to try all the activities that are described.

JOGGING FOR ENDURANCE

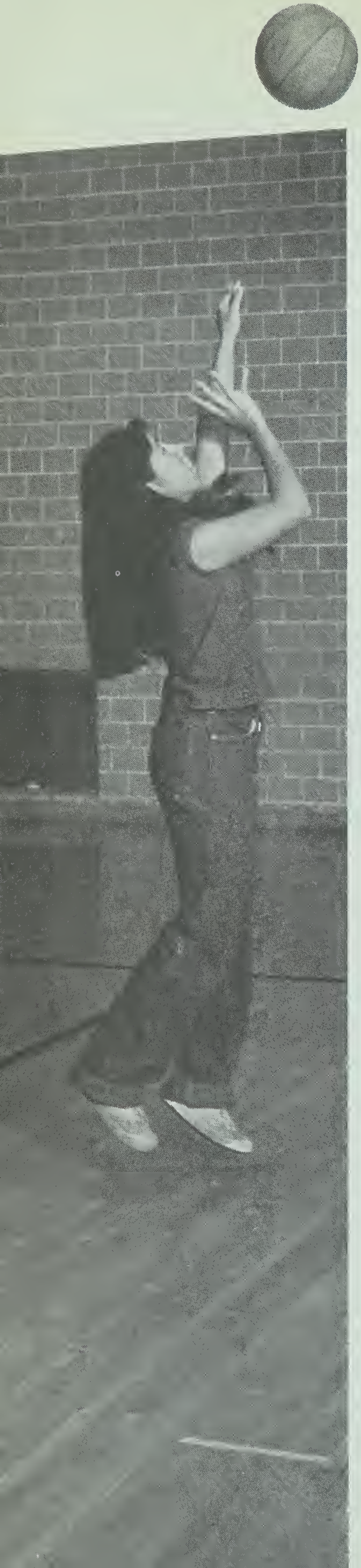


Jogging Hints:
Don't jog on your toes — you'll end up with aching muscles.

Jog at a rate that will keep your pulse between 150 and 175 beats per minute. Check your pulse periodically during the walking phase of your jogging exercise. If your heart rate is too high, jog less and walk more. If your heart rate is too low, jog more and walk less.

SIT-UPS FOR STRENGTH

Do sit-ups in sets. One set should consist of 10 to 15 sit-ups and a 2- to 3-minute rest period. Do three sets of sit-ups a day for ten days. For directions on how to do sit-ups, refer to the Sit-Ups Test on page 14.



You may want students to exercise every day for 10 days so that they have enough time to complete this activity while doing *Keeping Fit.*

EXERCISES FOR FLEXIBILITY

Do each of the flexibility exercises shown on pages 22 and 23. Do the exercises for ten days.

Now start the exercise program you planned. Exercise every other day for twenty days. (That's ten days of doing exercises). If your time is limited, exercise every day for ten days. Then take the Step Test (page 8), the Sit-Ups Test (page 14), and the Toe-Touch Test (page 20). Record your ratings and scores in your summary chart in the row labeled After Program.

- 5-3. Compare your *After Program* and *Before Program* ratings. Are the *After Program* ratings better? the same? worse?

5-3. Answers will vary.

It is quite possible that your ratings remained the same. This may be due to the short time that your exercise program lasted. Also, for a rating to change, some test scores may have to change a lot.

- 5-4. After the exercise program, was your recovery index *better*, the *same*, or *worse* than before the program? What part (or parts) of your body was improved by the exercise program?

For most people, jogging regularly will cause some improvement in their recovery index.

- 5-5. After the exercise program, was the number of sit-ups you could do *better*, the *same*, or *less than* before the program? What part (or parts) of your body was improved by the sit-up exercises?

5-5. Answers will vary, but many will be *better*. The abdominal muscles were improved by sit-ups.

You probably saw some improvement in your physical fitness after exercising for ten days. Exercising for more than ten days should bring about increased improvements. In fact, if you exercise long enough, your ratings for endurance, strength, and flexibility should improve.

- 5-6. After the exercise program, was your toe-touch score *better*, the *same*, or *less than* before the program? What part (or parts) of your body was improved by the flexibility exercises?

You can make an exercise program enjoyable by substituting sports activities for some or all of the exercises. Use the chart in Figure 19-1 (page 72) for help in choosing activities. Remember to do stretching exercises to warm up before taking part in sports activities. The activities you choose to do should keep you physically fit in all three traits — endurance, strength, and flexibility.

5-4. Answers will vary, but many will be *better*. The heart and possibly the leg and breathing muscles were improved by jogging.

5-6. Answers will vary, but many will be *better*. The leg muscles, tendons, and possibly the lower back muscles were improved by the flexibility exercises.

• 5-7. Do you plan to continue doing exercises in an exercise program? Why?

5-7. Answers will vary. If the answer is yes, the reason might be *to stay in shape.*

Activity 6
Strengthening Muscles

ACTIVITY EMPHASIS: The benefits of a strong heart; and the effect of exercise on the size of muscles in women and men.

MATERIALS PER LAB GROUP
None.

If you exercise regularly, what changes will you see? Rippling muscles? Beautiful body? Probably not. Most of the changes will not be obvious, but they're very important.

YOUR HEART

The heart is a muscle. It's the most important muscle in your body. By contracting and relaxing, your heart pumps blood through all the blood vessels in your body. Roughly, that's 100,000 kilometres (about 60,000 miles) of vessels.

When at rest, the average person's heart pumps about 70 to 80 times a minute. The heart rate increases when the muscles are working (being used). Then more blood is pumped to the muscles.

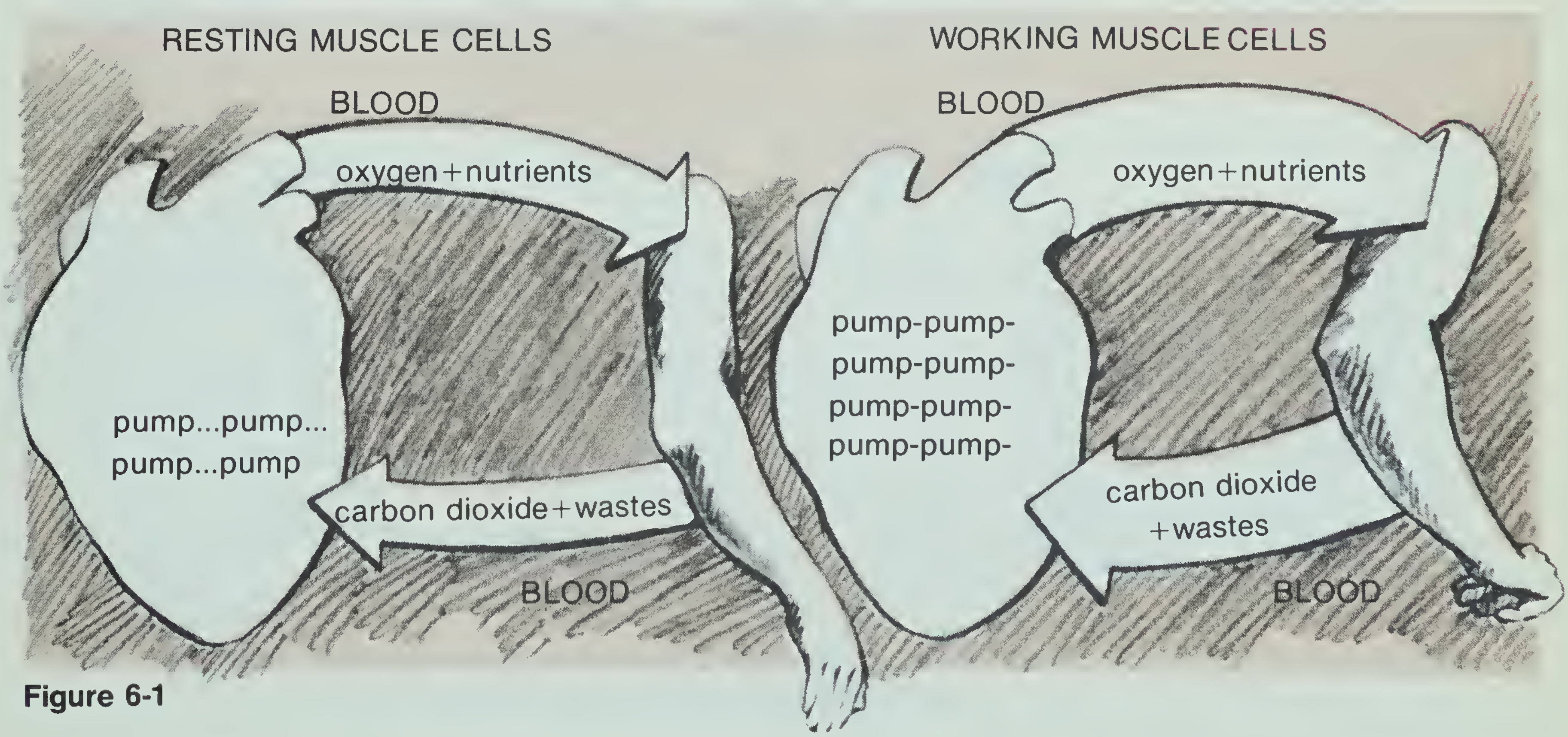


Figure 6-1

Refer to Figure 6-1 (page 27) when answering the following questions.

6-1. Oxygen and nutrients.

• 6-1. What does the blood carry *to* the muscle cells?

6-2. Carbon dioxide and wastes.

• 6-2. What does the blood carry *away* from the muscle cells?

6-3. The working muscle cells.

• 6-3. Compare the blood flow in the resting muscle cells and the working muscle cells. Which muscle cells need more blood?

6-4. It pumps (beats) faster.

• 6-4. How does your heart get more blood to your muscle cells?

Your endurance depends on the condition of your heart. If your heart is strong, your endurance will be good. If your heart is in poor condition, your endurance will not be good.

When you exercise regularly, your heart actually gets larger and stronger. A larger, stronger heart pumps more blood with each beat. More blood means more oxygen to the muscles. And more oxygen means better endurance. Study Figure 6-2. Then answer Questions 6-5 through 6-9.

Figure 6-2

6-5. Heart A: 750 ml, Heart B: 1000 ml

• 6-5. How many millilitres (ml) of blood will Heart A supply in 10 beats? How many will Heart B supply in 10 beats?

6-6. Heart A: 160 ml, Heart B: 200 ml

• 6-6. How many millilitres of oxygen will Heart A supply in 10 beats? How many will Heart B supply in 10 beats?

6-7. Heart A: 1600 ml, Heart B: 2000 ml

• 6-7. Suppose the heart rate is 100 beats per minute while walking. How much oxygen will Heart A supply in one minute? How much will Heart B supply in one minute?

6-8. Heart B.

• 6-8. Which heart (A or B) would supply more blood and oxygen to your body?

6-9. Heart B.

★ **6-9. With which heart (A or B) would you have more endurance for doing hard work? (See Figure 6-2.)**

Even at rest or during light exercise, your body's cells need oxygen. A strong, well-conditioned heart can pump more blood (and oxygen) with each beat than a weak heart. So a strong heart can beat slower than a weak heart, and it can rest between beats.

- 6-10. Suppose through regular exercise you lowered your resting heart rate from 75 to 65 beats per minute. How many heart beats would you "save" each day?
  Hint: *Beats saved per min x 60* (min/hr) x *24* (hr/day) = *Beats saved per day*

Although no one will guarantee it, a well-conditioned heart that beats slowly will probably last longer than a heart that beats quickly.

★ **6-11. A strong heart that beats slowly probably will last longer than a heart that beats quickly. Why?**

6-10. 10 X 60 X 24 = 14,400 heart beats saved per day.

6-11. A strong heart that beats slowly can rest between beats. The rest periods probably allow the heart to last longer.

MUSCLES THAT MOVE YOUR BODY

You've seen how exercise affects your heart. Now you'll see how exercise affects the muscles that move your body. These muscles are made up of long thin cells called *fibers*. When you exercise regularly, your muscles get stronger. This is because your muscle fibers get larger and more fibers are used. (See Figure 6-3.)

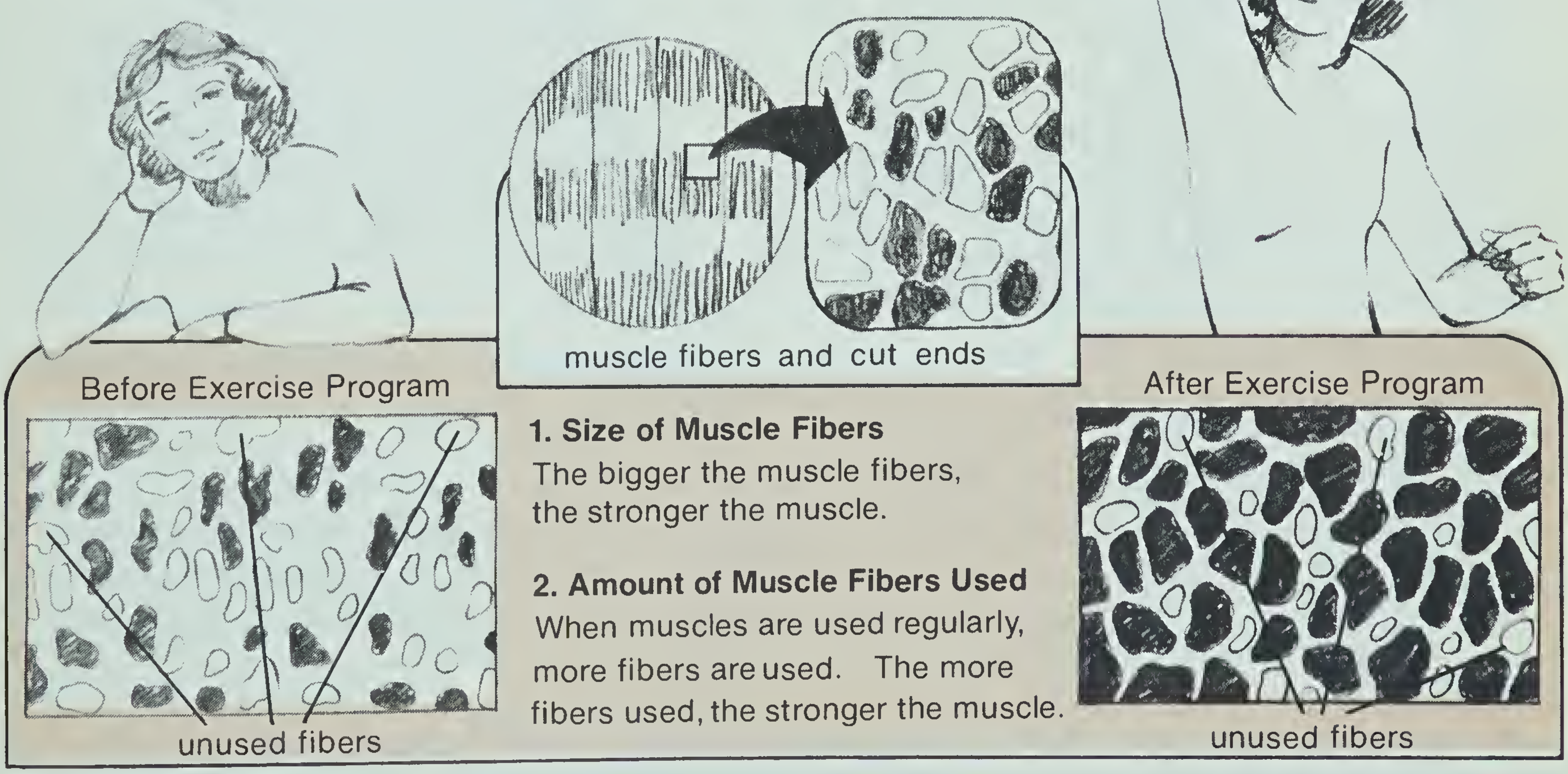


Figure 6-3

6-12. The muscle fibers get larger and more fibers are put to use.

★ 6-12. **Why do your muscles get stronger when you exercise regularly?**

Women usually have smaller muscles than men. This is true even when women exercise vigorously, over a long period of time.

Some students may be surprised that women have some male sex hormones.

The male sex hormone *testosterone* seems to be related to muscle fibers getting bulkier through exercise. Although bulging muscles are much more prevalent in males than in females, it varies from person to person.

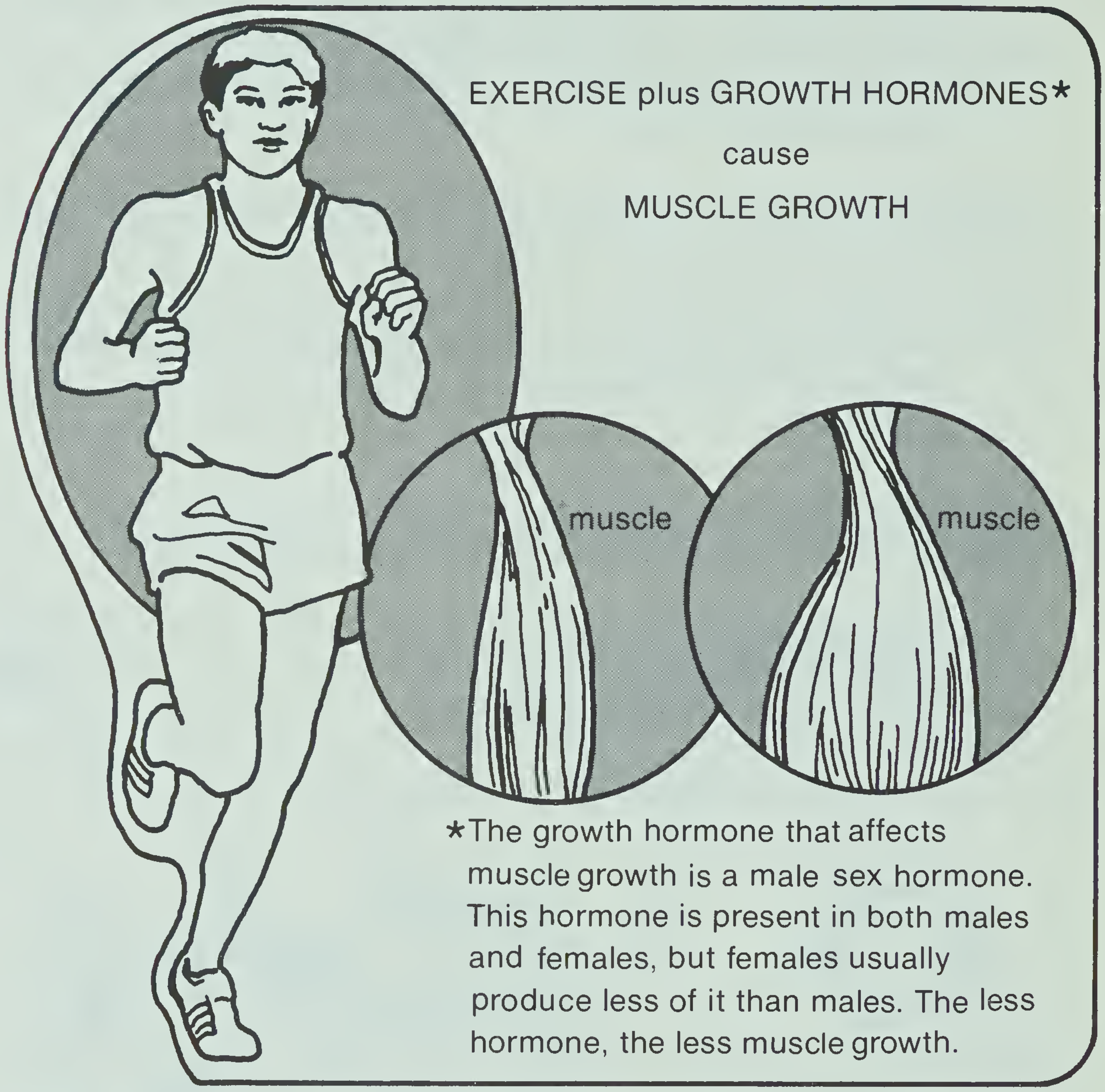


Figure 6-4

6-13. Usually a woman's body does not produce enough of the male sex hormone to greatly affect muscle growth.

★ 6-13. **As women get stronger, they usually don't get bulging muscles. Why?**

Remember — exercising regularly will cause many favorable changes in your body. But exercising occasionally will not produce as many favorable changes. And if you exercise regularly but then stop, your heart and other muscles will slowly return to their previous condition.

6-14. If you stopped exercising, your body would gradually lose the fitness gained by exercising regularly.

• 6-14. Suppose you're on a school athletic team and exercise regularly to improve your fitness. Why should you continue to exercise even when the season is over?

ACTIVITY EMPHASIS: A description of 20 major bones in the body with the common and scientific names of the bones; an investigation for how muscles move bones.

Activity 7
Muscles and Bones

MATERIALS PER LAB GROUP
See Materials and Equipment, pp. TM 3-4.
See also Advance Preparation, p. TM 6.

The *Skeleton Puzzle,* supplied separately, is needed for this activity. Be sure to have enough copies available.

Your bones support your body. Without bones, you'd be a shapeless mass. The human body has about 206 different bones, each with a different name. You probably know and use many of the common names.

Some bones and their scientific names are shown in Figure 7-1. Study the illustration. Then get the *Skeleton Puzzle,* a crossword puzzle. There should be a copy of the puzzle in the classroom. If not, ask your teacher for one.

- 7-1. Do the *Skeleton Puzzle*. 7-1. For answers to the puzzle, refer to the spirit duplicating master for the *Skeleton Puzzle.*

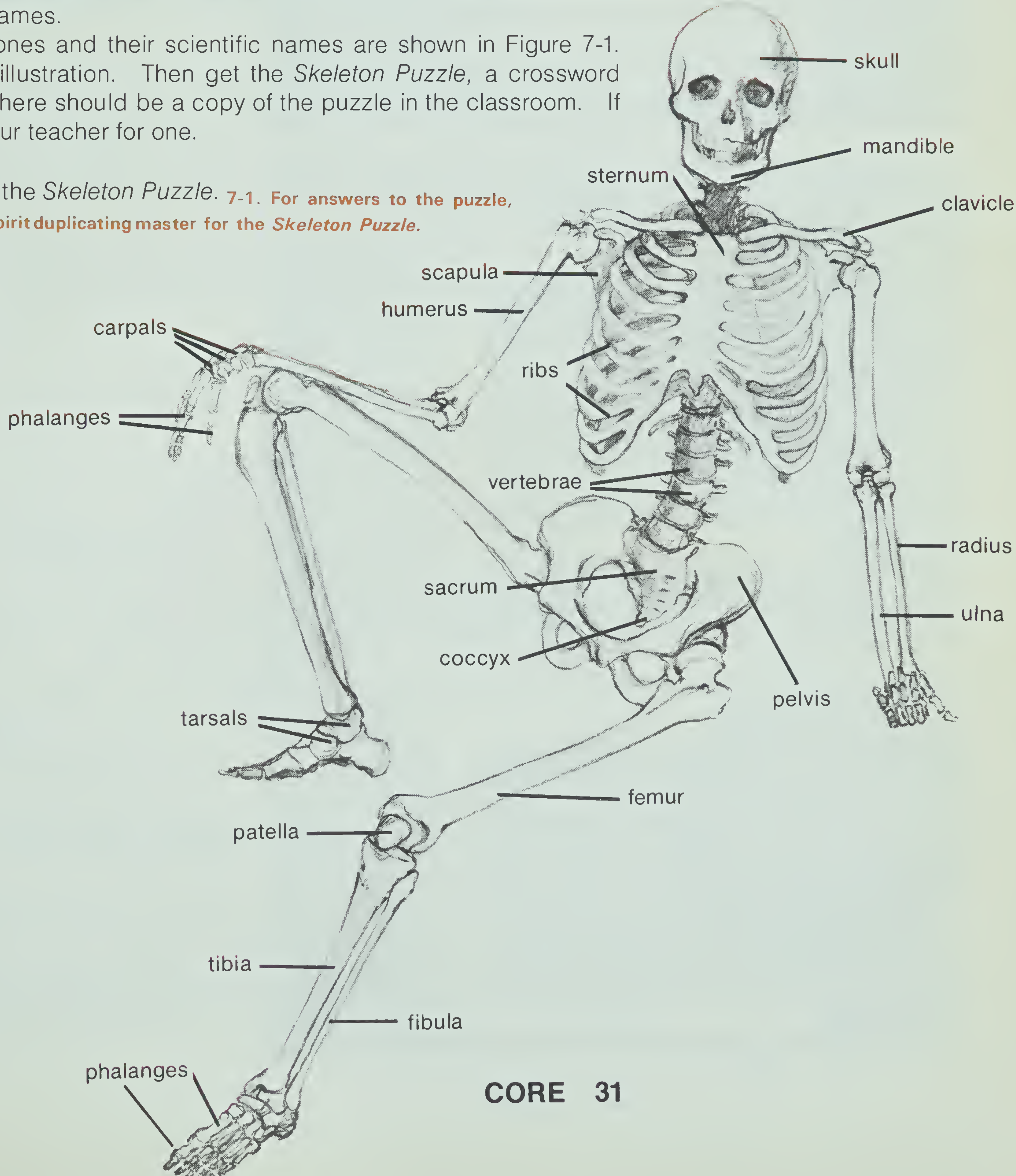


Figure 7-1

When you've completed the *Skeleton Puzzle*, find a partner who has also completed it. See how fast you can identify the 20 bones used in the puzzle. Point to an area of your body where one of the bones is located. Ask your partner to identify the bone by its scientific name. Then your partner points to a bone and you identify it. Take turns until both of you know the scientific names for the 20 bones.

7-2. a. skull, b. carpals, c. clavicle, d. tibia, e. mandible, f. tarsals

★ 7-2. What are the scientific names for the following bones?
a. head b. wrist c. collarbone d. shin e. jaw f. ankle

A bone sample or a human skeleton would be most useful for reference.

Although they don't look it, bones are firm only on the surface. Inside, they contain delicate, spongy-looking material and sometimes a cavity. The inside of a bone is shown in Figure 7-2.

A bone's spongy-looking material is made of many bony bars. These bars make the bone light, but strong. The bars act as braces to reinforce the outside shell of the bone. The bony bars are similar to the braces that hold up a bridge. (See Figure 7-2.)

Exercise increases the amount of bars in your bones. As more bars form, your bones get stronger. They're better able to support your body.

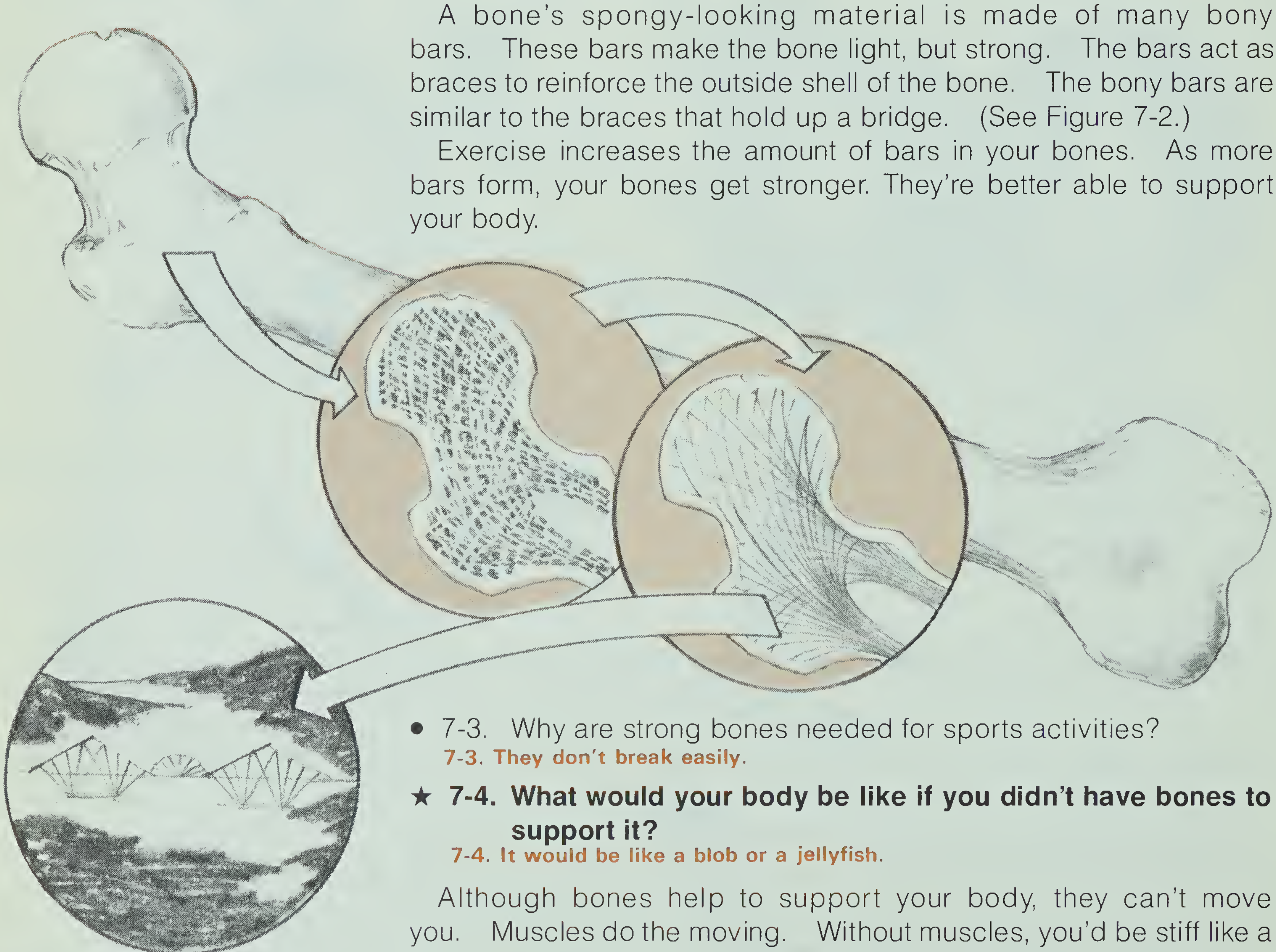


Figure 7-2

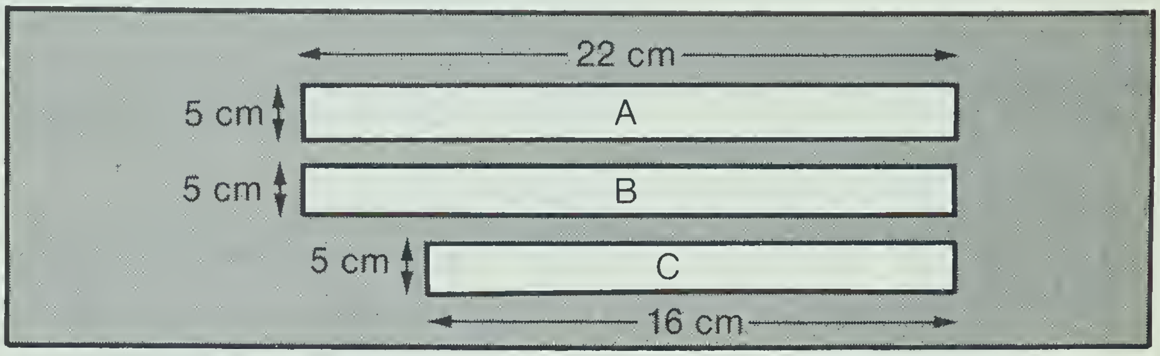
• 7-3. Why are strong bones needed for sports activities?
7-3. They don't break easily.

★ 7-4. What would your body be like if you didn't have bones to support it?
7-4. It would be like a blob or a jellyfish.

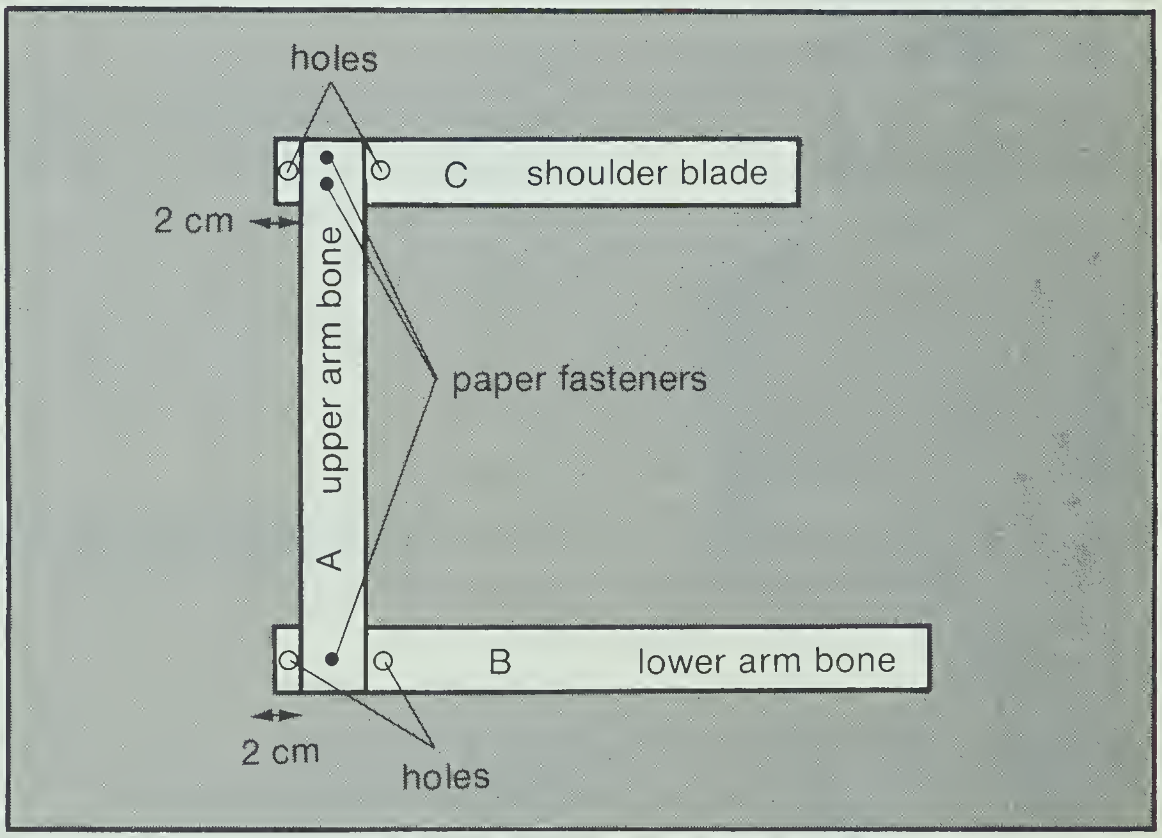
Although bones help to support your body, they can't move you. Muscles do the moving. Without muscles, you'd be stiff like a statue. To see how muscles and bones work together to move your body, make a model of your arm. You'll need the following materials:

metric ruler
scissors
stiff cardboard, about 22 cm x 15 cm
2 pieces of heavy string, each at least 40 cm long
3 paper fasteners
paper punch

A. Cut three strips of cardboard as shown and label them *A, B,* and *C*.



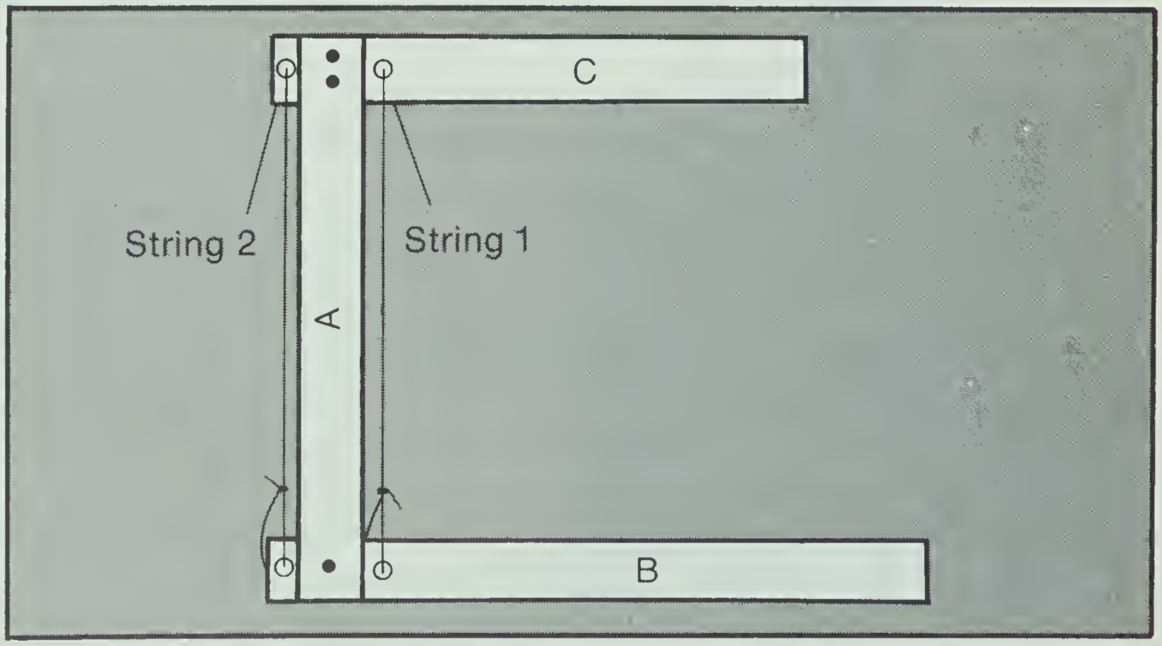
B. Place Strip A on top of Strips B and C (about 2 cm of Strips B and C extend beyond Strip A). Use three paper fasteners to fasten the strips together.



C. Punch two small holes in Strip B and two small holes in Strip C.

What you have made is a crude model of a shoulder (Strip C), an upper arm bone (Strip A), and a lower arm bone (Strip B). Now the model needs a muscle.

D. Get two pieces of string and call them *String 1* and *String 2*. Tie one end of String 1 to a hole in Strip B. Thread the other end of String 1 through the corresponding hole in Strip C. Repeat this procedure with String 2 to connect the other two holes.



E. Pull the loose end of String 1. Then pull the loose end of String 2.

7-5. The part of String 2—between the two holes—got longer. The "lower arm bone" moved up.

7.6. The part of String 1—between the two holes—got longer. The "lower arm bone" moved down.

7.7. a

- 7-5. When you pulled String 1, what happened to String 2? What happened to the "lower arm bone"?

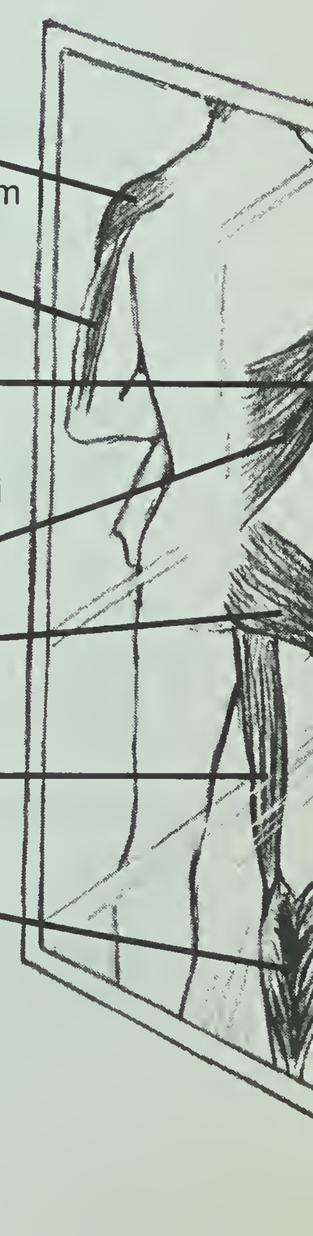
- 7-6. When you pulled String 2, what happened to String 1? What happened to the "lower arm bone"?

The strings in the model worked as a pair. That's how your muscles work — in pairs. In a muscle pair, each muscle takes turns pulling on a bone. When one muscle pulls, it contracts and gets shorter. The other muscle relaxes, stretches, and gets longer.

★ **7-7. How does a pair of muscles move a bone?**
a. One muscle contracts and the other relaxes.
b. Both muscles contract.
c. Both muscles relax.

When a muscle contracts, it becomes thicker. Raise and lower your forearm (lower arm). Can you feel what happens to the muscles in your upper arm? These muscles are called *biceps* and *triceps*. The illustration below shows how your biceps and triceps move your forearm.

Other important muscle pairs are shown in the illustration below. Try the movements described. Can you feel your muscles contract?

• 7-8. Draw a table like the one in Figure 7-3. Then complete the table by identifying three more pairs of muscles and the movements they produce.

7-8. Deltoid/latissimus dorsi—raises arm/lowers arm, Rectus femoris/gluteus maximus—bends hip/straightens hip, Gastrocnemius/tibialis anterior—points foot/raises foot

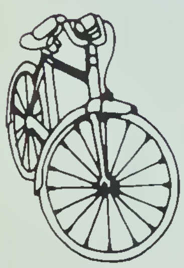
ACTIONS PRODUCED BY MUSCLES

MUSCLE PAIR	ACTION
Biceps/Triceps	Bend elbow/Straighten elbow

Figure 7-3

• 7-9. Suppose both muscles in a pair contracted with equal force and at the same time. Describe what might happen and why.

7-9. The bones would not move. There has to be a relaxed muscle and a contracted muscle for movement to occur.



Activity 8
Tendons and Joints

ACTIVITY EMPHASIS: The role of tendons in the human body; and a description of the four types of bone joints.

MATERIALS PER LAB GROUP
None.

You've probably noticed that dancers, athletes, and cheerleaders can move their bodies freely and easily. One reason they can do this is because their joints move well. (A joint is where two bones meet.) The more movable a joint is, the more flexible it is. Try the Knee-Joint Test to find out how flexible your knee joints are.

Knee-Joint Test

A. Bend your knees slightly. Keeping your knees bent, reach down and touch the floor with the tips of your fingers.

B. Try to straighten your legs.

8-1. Answers will vary. Some students probably will feel pain, tightness, stretching, or pulling.

• 8-1. What kind of feeling did you get in the back of your legs as you tried to straighten them in the Knee-Joint Test?

Did you have trouble straightening your legs? If so, your knee joints probably are not very flexible. That is, the tendons and muscles in the back of your legs are not very stretchable.

Tendons are cord-like structures that connect muscles to bone. Figure 8-1 shows the tendons and muscles that surround your knee joint. Notice that the tendons cross (go over) the knee joint. Tendons always cross a joint.

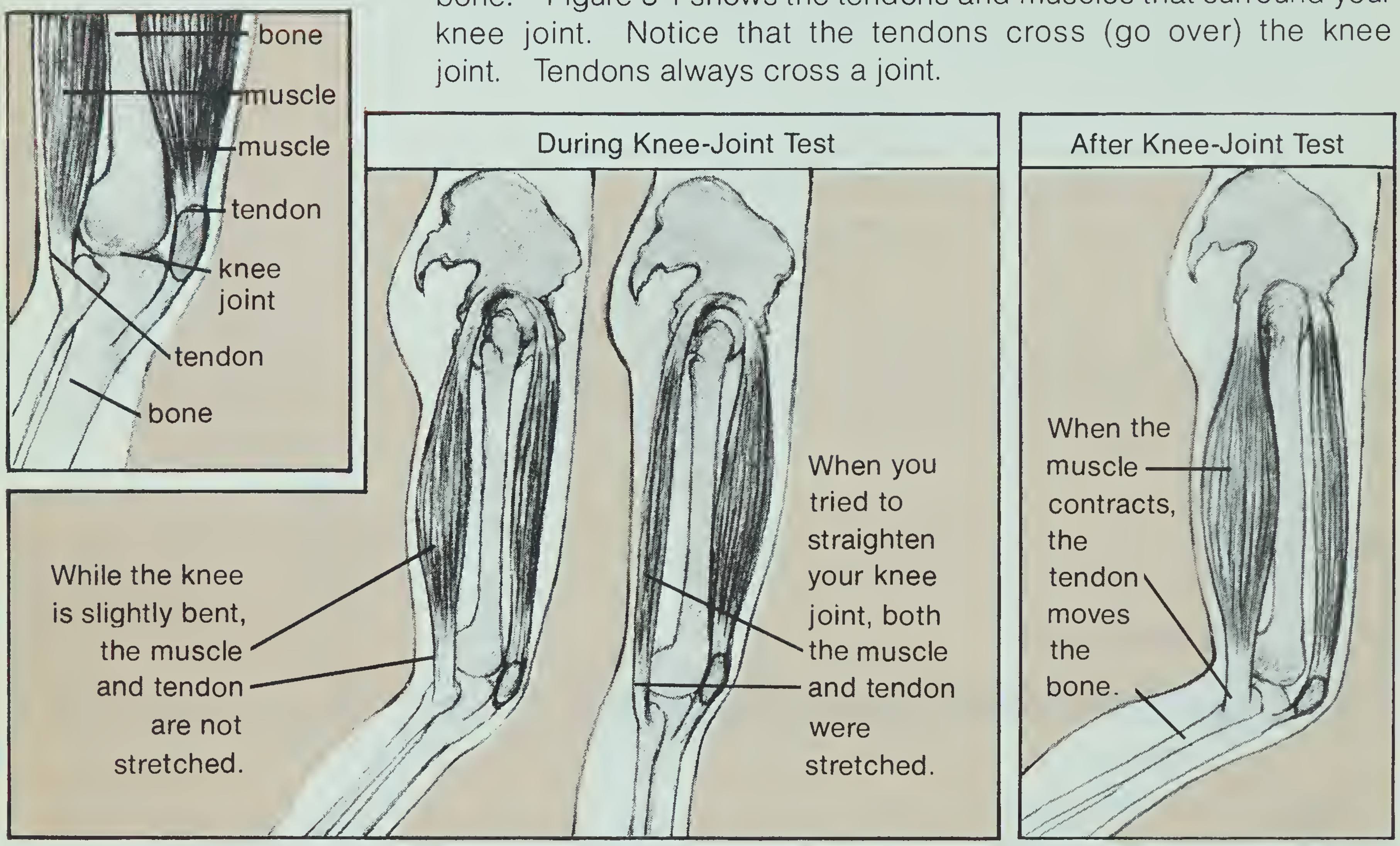


Figure 8-1

Suppose you weren't physically fit. Then your tendons and muscles wouldn't stretch much. You probably couldn't straighten your knees in the Knee-Joint Test. And you probably would feel tightness in the back of your legs during the test. Figure 8-1 shows how leg muscles and tendons *should* act during and after the Knee-Joint Test.

8-2. They connect muscles to bones. They help to move the bones in a joint when a muscle contracts.

★ 8-2. What are the two main roles of tendons?

You can make your tendons and muscles more stretchable by regularly doing stretching exercises. Then your joints will move more freely and your body will be more flexible.

Joint movement may be limited by factors other than tight tendons and muscles. Movement also may be limited by the shape of bones and the way bones are joined.

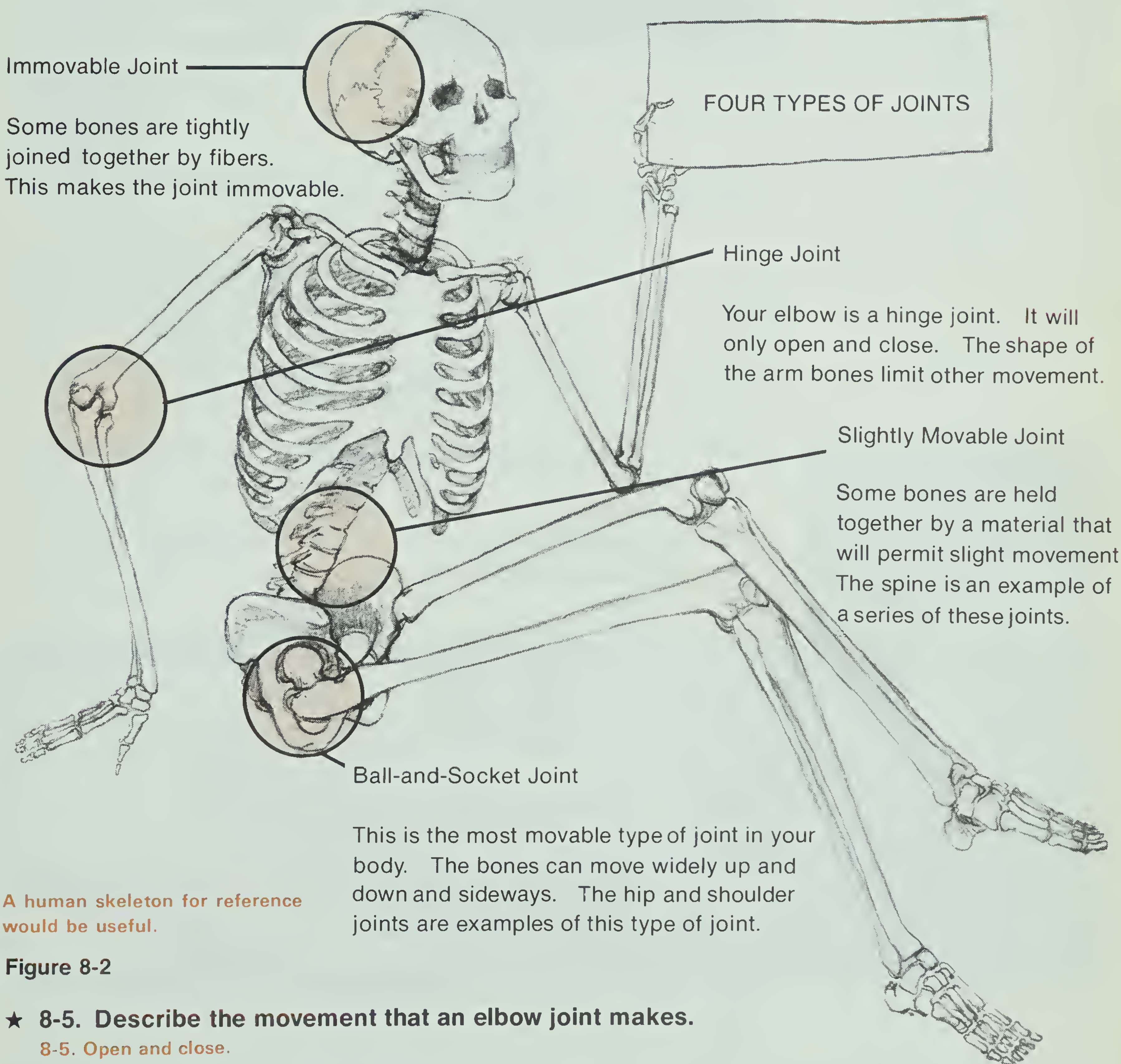
• 8-3. Suppose your tendons were in poor shape. How would this affect the rest of your body?

8-3. The joints in your body would not move freely.

• 8-4. Suppose you have trouble moving your elbow. Describe why movement may be limited.

8-4. Your tendons and muscles may not have enough stretchability; the shape of the bones in your arm may limit movement; the way the bones are joined may limit movement.

Four types of joints are shown in Figure 8-2. Study the figure, then answer Questions 8-5 and 8-6.



A human skeleton for reference would be useful.

Figure 8-2

★ **8-5. Describe the movement that an elbow joint makes.**

8-5. Open and close.

• 8-6. Name another hinge joint that's in your body (besides your elbow).

8-6. Knee.

8-7. A ball-and-socket joint permits free movement in all directions. However, a complete rotation (360°) in the hip cannot be made because movement is limited by the shape of the bones in the joint.

8-8. Shoulder.

8-9. a-4, b-1, c-2, d-5

Do Steps A and B to see how a ball-and-socket joint works.

A. Make a fist. Put your fist in the palm of your other hand. Close your fingers lightly around your fist.

B. Twist your fist while holding it lightly.

- 8-7. Describe movements that *cannot* be made with a ball-and-socket joint.

- 8-8. Name another ball-and-socket joint that's in your body (besides your hip).

The many bones that form joints have different shapes. Some shapes allow more movement than others. Some muscles and tendons allow more movement than others (depending on their condition). As you move, notice how your joints move. Notice the limitations of some joints — the things they can't do.

★ **8-9. Match each type of joint with one of its locations in your body.**

Type of Joint	**Location in Body**
a. ball-and-socket	**1. knee**
b. hinge	**2. spine**
c. slightly movable	**3. finger**
d. immovable	**4. shoulder**
	5. head

ACTIVITY EMPHASIS: The cause and treatment of common painful muscle problems.

MATERIALS PER LAB GROUP
None.

Activity 9
Muscle Aches and Pains

At one time or another you've probably had a painful muscle. What causes a muscle to cramp or become stiff and sore? What can you do to relieve the pain? How do you treat more serious problems like muscle bruises and pulls? You'll be able to answer these questions after you do this activity.

Muscles work in pairs to produce most of our movements. As one muscle in a pair contracts and shortens, the other relaxes and stretches. Figure 9-1 shows how the muscles in your upper arm work. These muscles are called *biceps* and *triceps*. Move your forearm (lower arm) up and down. Feel your biceps and triceps contracting and relaxing.

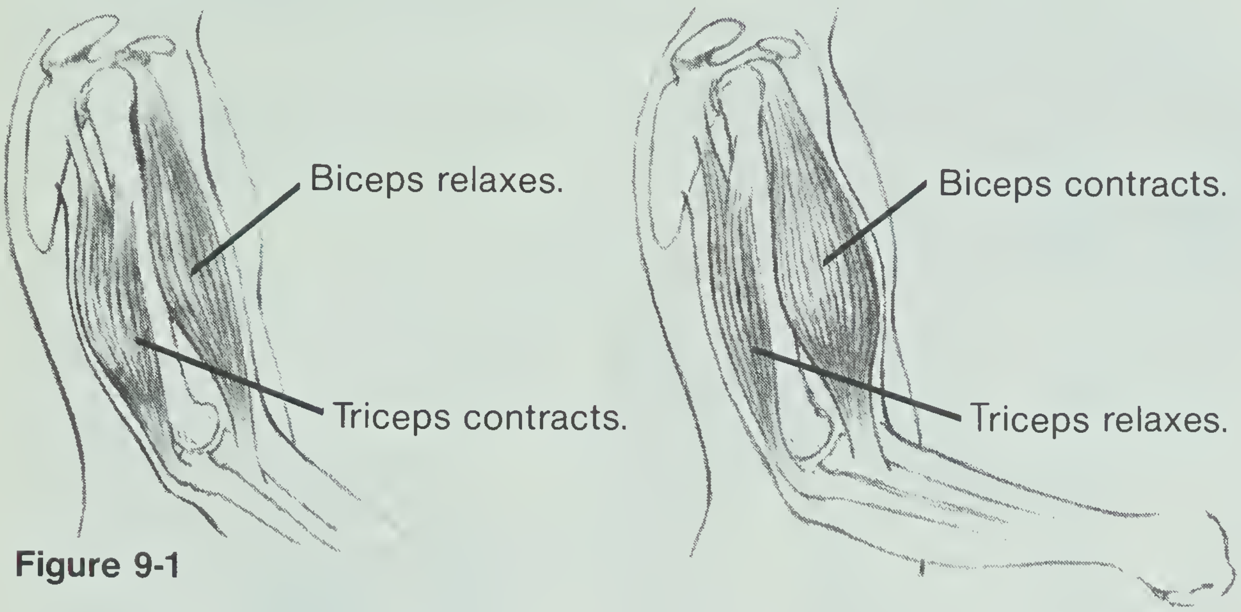


Figure 9-1

SORE AND STIFF MUSCLES

Sore or stiff muscles usually occur when you do some sort of new activity. The activity may cause your muscles to overwork — to stretch more than usual. Then some of the muscle fibers tear. Even though the breaks are small (they're microscopic), they can cause pain. Usually there are no blood vessels broken and there's no swelling.

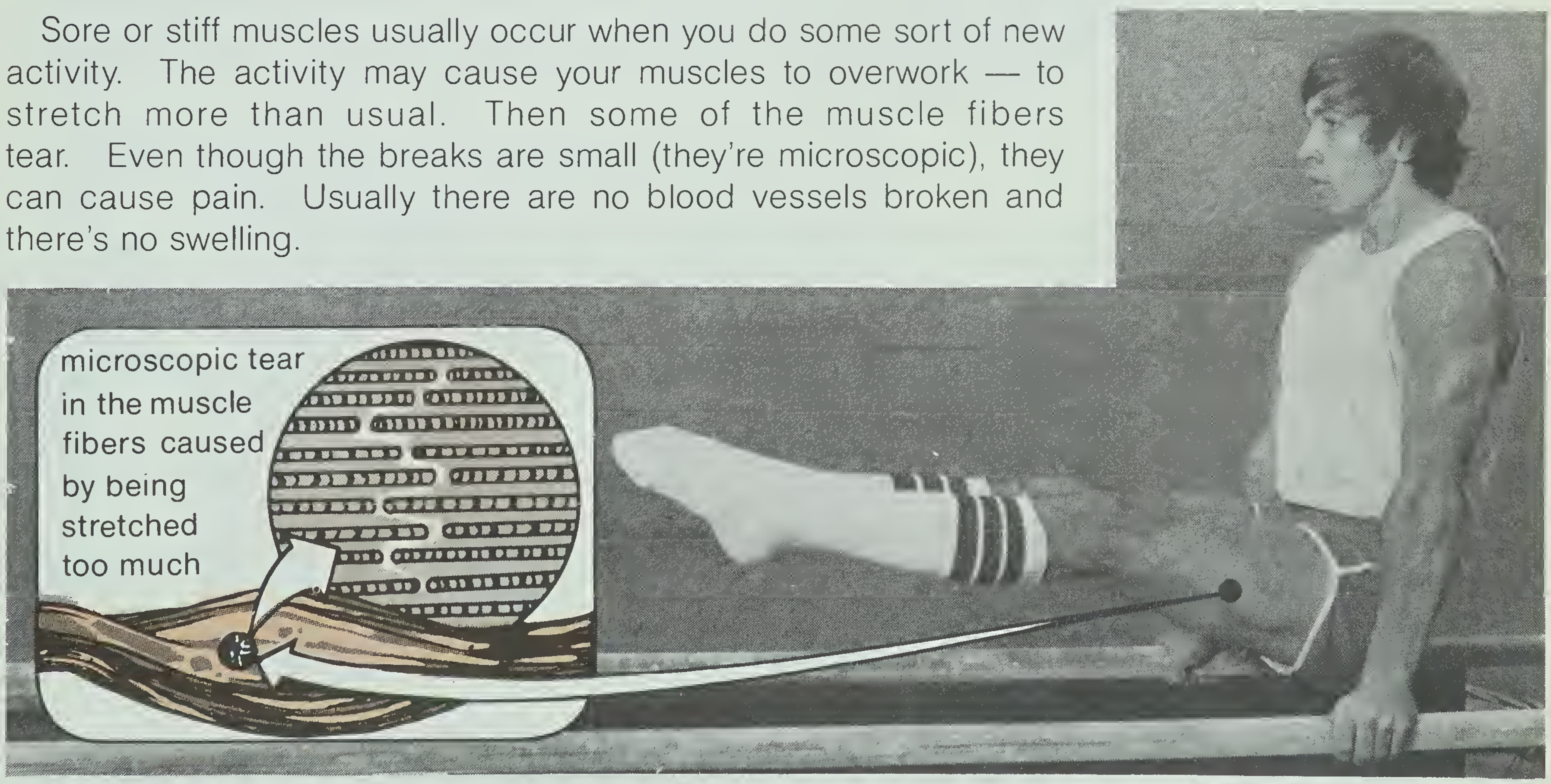


Figure 9-2

- 9-1. Look at Figure 9-2. Which muscles in the gymnast's legs are stretching more than they would in everyday activities?

9-1. Muscles in the upper part of his legs.

The body usually repairs small tears quickly. And muscle soreness goes away in a few days. You can speed up the healing process by increasing the blood's circulation to the damaged areas. Figure 9-3 shows several ways to do this. As blood circulation is increased, muscle soreness is relieved.

Figure 9-3

9-2. If it is sore the next day, you probably tore some muscle fibers in the muscle.

9-3. They increase the blood's circulation to the sore muscle thus speeding up the healing process.

★ **9-2. When you overwork a muscle (stretch it more than usual), it probably will be sore the next day. Why?**

• 9-3. How do massages, heat, and light exercise relieve muscle soreness?

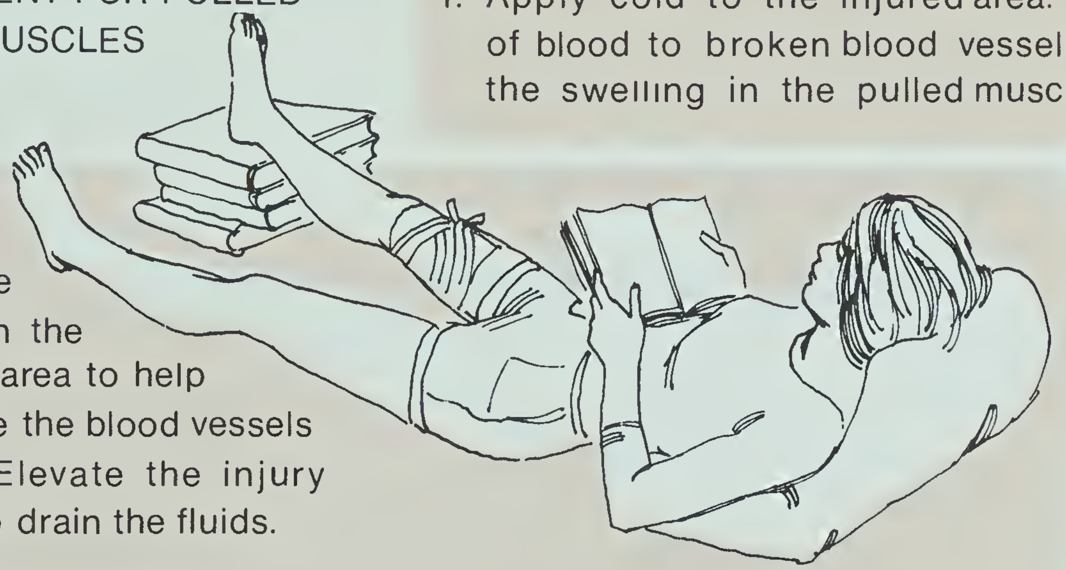
MUSCLE PULLS

If there is great stress on a muscle, some of the large fibers pull or tear apart. As the muscle fibers tear, blood vessels break and swelling occurs. When you pull a muscle, you usually feel a sudden snap or sharp pain. Because there is damage to the muscle fibers and blood vessels, special treatment is required. (See Figure 9-4.)

TREATMENT FOR PULLED MUSCLES

1. Apply cold to the injured area. This slows the movement of blood to broken blood vessels and reduces the swelling in the pulled muscle.

2. Put a pressure wrap on the injured area to help squeeze the blood vessels shut. Elevate the injury to help drain the fluids.



CAUTION **Do not make the pressure wrap too tight!**

3. Rest the injury to keep the fibers and blood vessels from tearing again.

4. After 2 to 3 days, when the swelling has been controlled, apply heat. This increases the circulation and speeds up healing.

5. Full recovery may take from 1 to 3 weeks. Only light exercise should be attempted during this time.

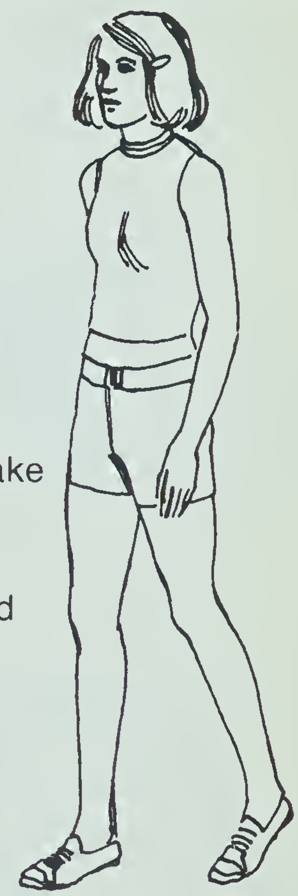


Figure 9-4

- 9-4. Why does swelling occur in a pulled muscle and not in a stiff or sore muscle?

★ **9-5. Describe two ways to reduce the swelling in a pulled muscle.**

- 9-6. After pulling a muscle, how long should you wait before vigorously exercising it? Why?

9-4. In a pulled muscle, there are broken blood vessels. As a result, blood and other fluids accumulate and cause swelling. No blood vessels are broken in stiff or sore muscles.

9-5. Any two of these answers: *apply cold; apply a pressure wrap; elevate the injury.*

9-6. One to three weeks. That's how long it takes for the injured muscle to heal.

BRUISES

A bruised muscle is often called a *charley horse*. This painful injury results from a sharp blow to a muscle. Muscle fibers are bruised and blood vessels are broken. The treatment is the same as that for a pulled muscle (see Figure 9-4, page 41).

9-7. a. apply cold; b. apply pressure wrap; c. elevate; d. rest; e. when the swelling goes down, apply heat; f. light exercise.

★ 9-7. What are the steps to follow when treating a charley horse?

MUSCLE CRAMPS

A mysterious muscle problem is a *cramp* or *muscle spasm*. The muscle contracts suddenly and painfully. This often happens in leg muscles.

Scientists aren't sure what causes a muscle to cramp. What seems to be involved is *fatigue* and an *excess loss of body chemicals* through perspiration. If you get tired or sweat heavily during exercise, you might develop muscle cramps. Experts have these suggestions for preventing cramps: rest when you get tired and drink liquids to replace lost chemicals and body fluids. (Drink salted water or special thirst quenchers — regular "soft drinks" do not contain the same type chemicals that were lost.)

Sometimes a muscle will cramp while you're exercising, but usually it'll cramp after you've stopped. To treat a cramped muscle, slowly stretch the muscle until the pain goes away. Then slowly release it. Repeat this stretching procedure if the cramp returns. When the muscle has stopped cramping, apply heat to keep it relaxed. Figure 9-5 shows some stretching exercises you can do for cramped muscles.

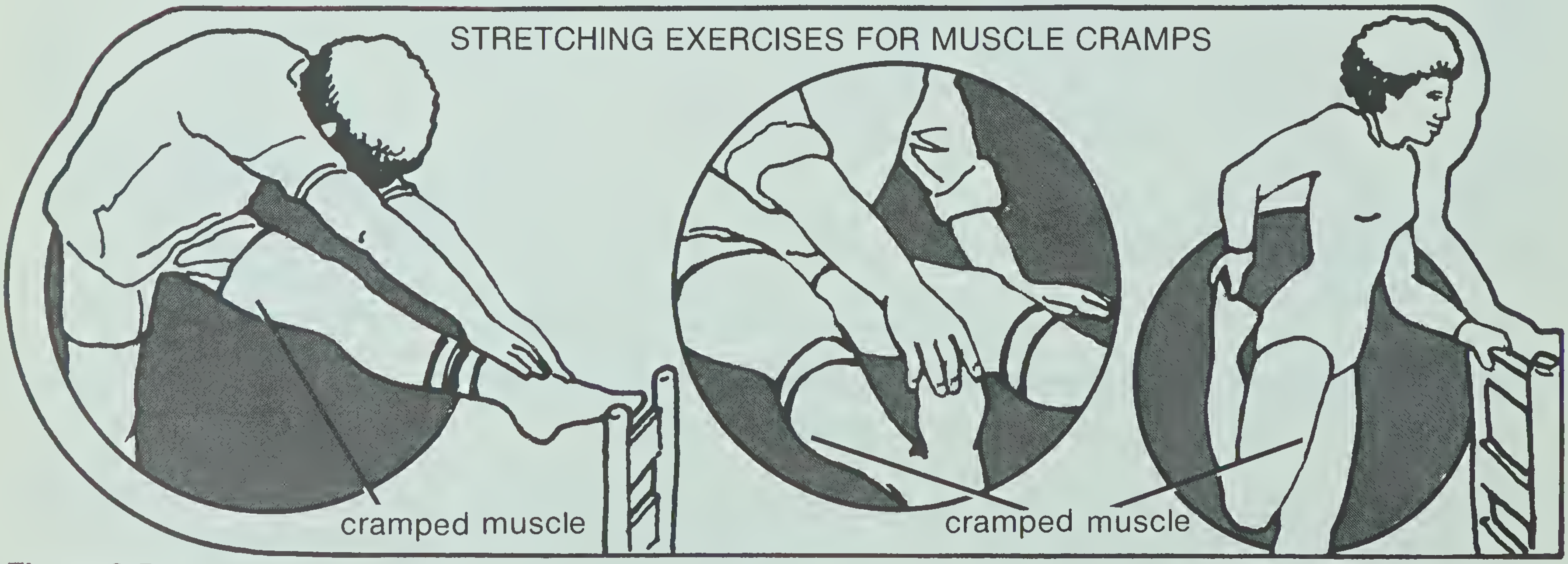


Figure 9-5

9-8. Raise and stretch leg, resting foot on object (chair) that's slightly below waist level. Lean forward.

• 9-8. Suppose you had a cramped muscle in the back of your upper leg. What would you do to relax the muscle?

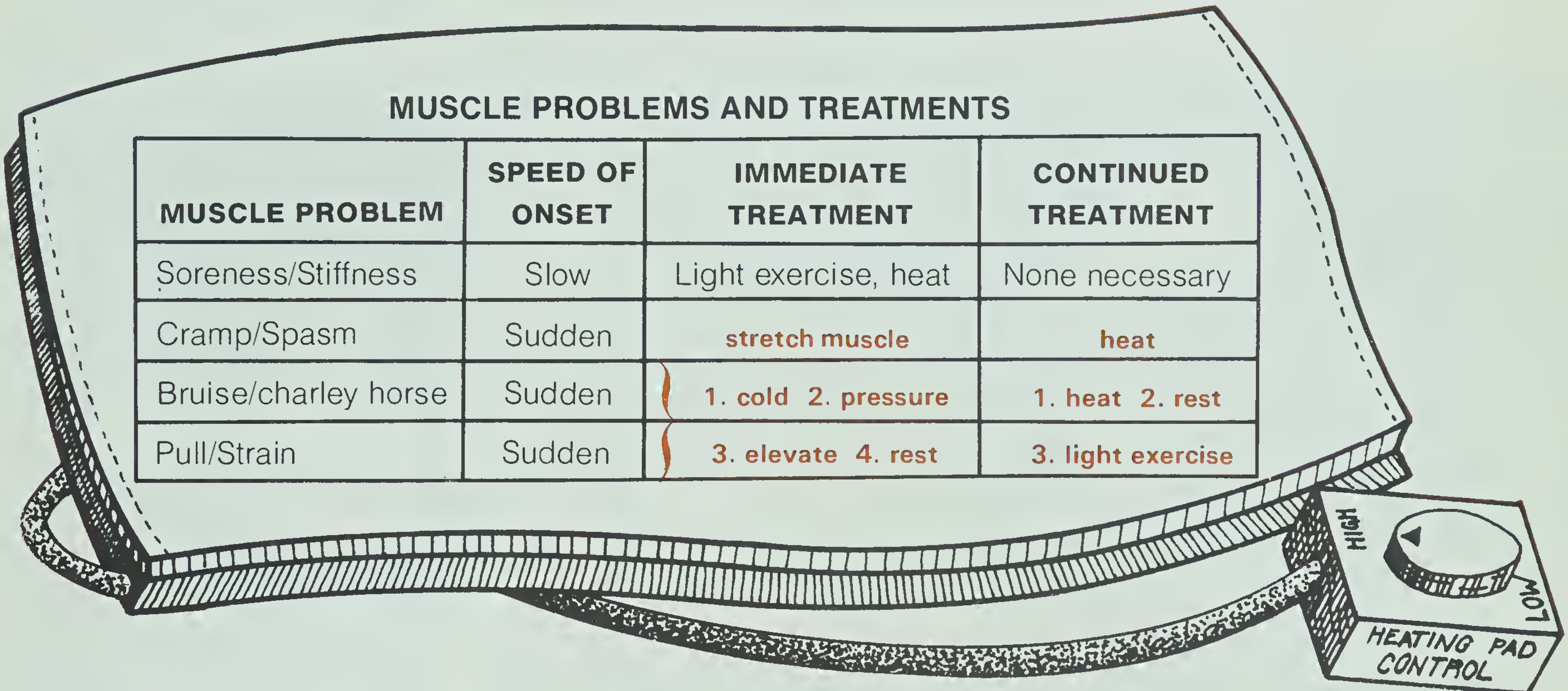
• 9-9. Describe a stretching exercise that would help to relax a cramped muscle in the front of your upper leg.

9-9. Using the leg with the cramped muscle, bend the knee; hold your foot and press it toward the back of your leg. (With your other hand, hold onto something that will help you keep your balance.)

• 9-10. Suppose you were sound asleep. All of a sudden your calf muscle (back of lower leg) cramped and the pain wakened you. What would you do to relieve the cramp?

9-10. Sit up with legs extended. Hold toes of cramped leg. Keep knee straight and pull top of foot towards body. Or get out of bed, stand on your tiptoes, lean against a solid object and try to push your heels to the floor.

• 9-11. In your notebook, draw a chart like the one in Figure 9-6. Then complete the chart.



MUSCLE PROBLEMS AND TREATMENTS

MUSCLE PROBLEM	SPEED OF ONSET	IMMEDIATE TREATMENT	CONTINUED TREATMENT
Soreness/Stiffness	Slow	Light exercise, heat	None necessary
Cramp/Spasm	Sudden	stretch muscle	heat
Bruise/charley horse	Sudden	1. cold 2. pressure	1. heat 2. rest
Pull/Strain	Sudden	3. elevate 4. rest	3. light exercise

Figure 9-6

A proper warm-up of stretching exercises will help prevent muscle soreness and damage. Muscles that have been warmed up are less likely to tear than muscles that have not been warmed up.

• 9-12. Describe exercises you could do to warm up your leg muscles.

9-12. Stretching exercises, jogging.

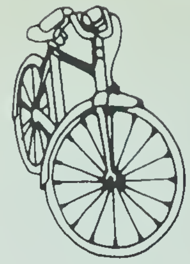
★ **9-13. Match the following muscle problems with their treatments.**

9-13. a-2, b-2, c-1, d-3

Muscle Problem	**Treatment**
a. charley horse (bruise)	**1. stretch the muscle**
b. pull or strain	**2. cold, pressure, elevate, rest, heat 2 days after injury, light exercise**
c. cramp or spasm	**3. light exercise and heat**
d. soreness or stiffness	

ACTIVITY EMPHASIS: The causes, symptoms, and treatments of minor injuries to bone joints.

MATERIALS PER LAB GROUP See Materials and Equipment, pp. TM 3-4.



Activity 10
Jarring The Joints

What can go wrong with your joints? Before you find out, you'll need to know what a joint is and how it is put together.

A joint is where major bones come together. Most joints are movable. Your knee and elbow are movable joints. Other joints are in your jaw, shoulders, wrists, fingers, and feet. Figure 10-1 shows a movable joint — a knee joint. Notice that it's made up of blood vessels, ligaments, and tendons.

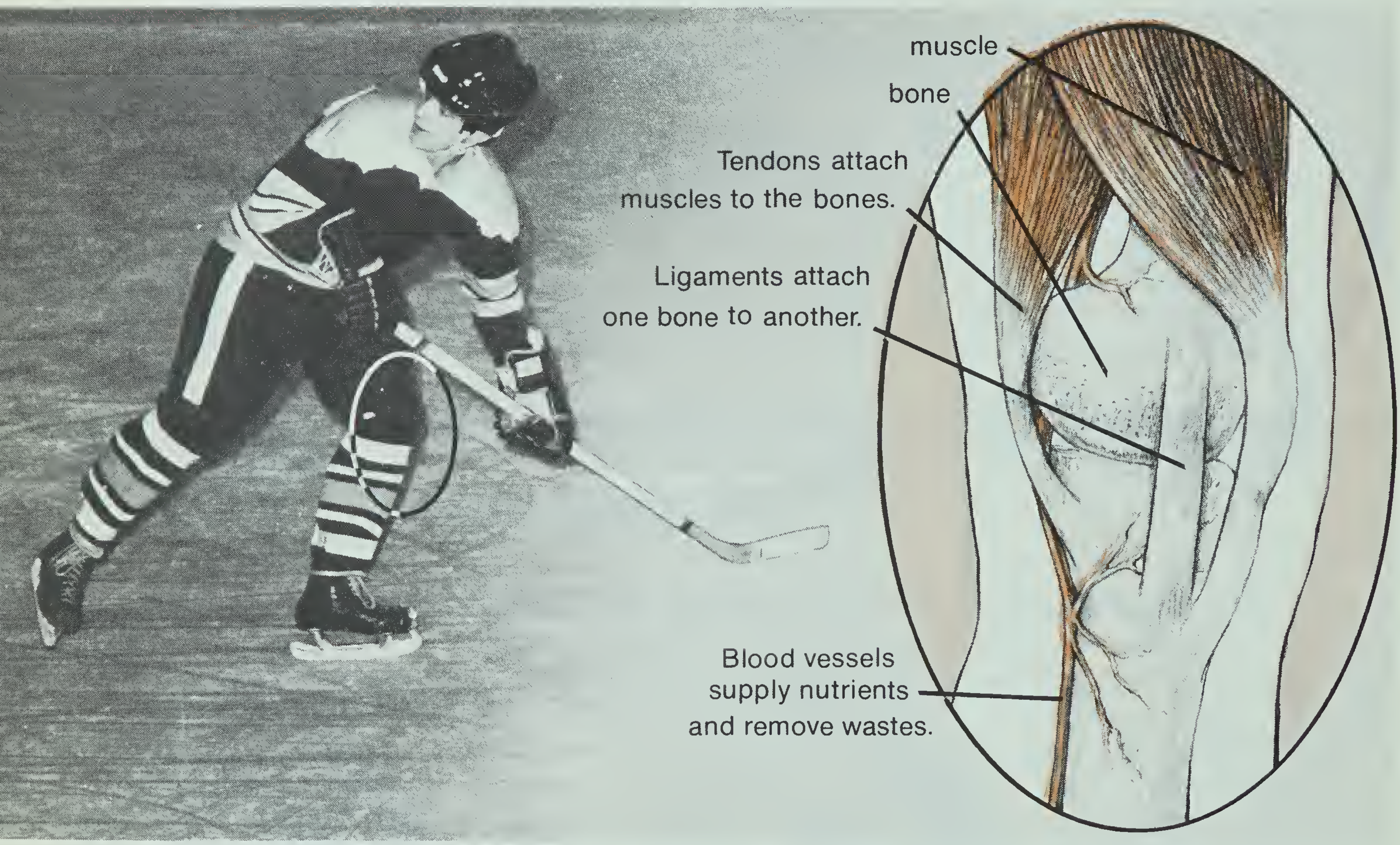


Figure 10-1

10-1. Tendon.

10-2. Ligament.

- 10-1. What structure attaches a muscle to a bone?

- 10-2. What structure attaches a bone to a bone?

Two types of injuries can happen to joints: sprains and dislocations. In this activity, you'll learn about both injuries. First you'll study sprains — where they happen, what causes them, and recommended treatment.

SPRAINS

A sprain is a severe twisting of a joint. The twisting tears or stretches the ligaments and tendons in the joint. Blood vessels break causing internal bleeding and then swelling. Sprains happen most often to ankle, thumb and knee joints. A badly sprained joint should be x-rayed to find out if any bones are broken.

Treatment for a sprain should decrease swelling and speed up the natural healing process. Figure 10-2 shows how to treat a sprain.

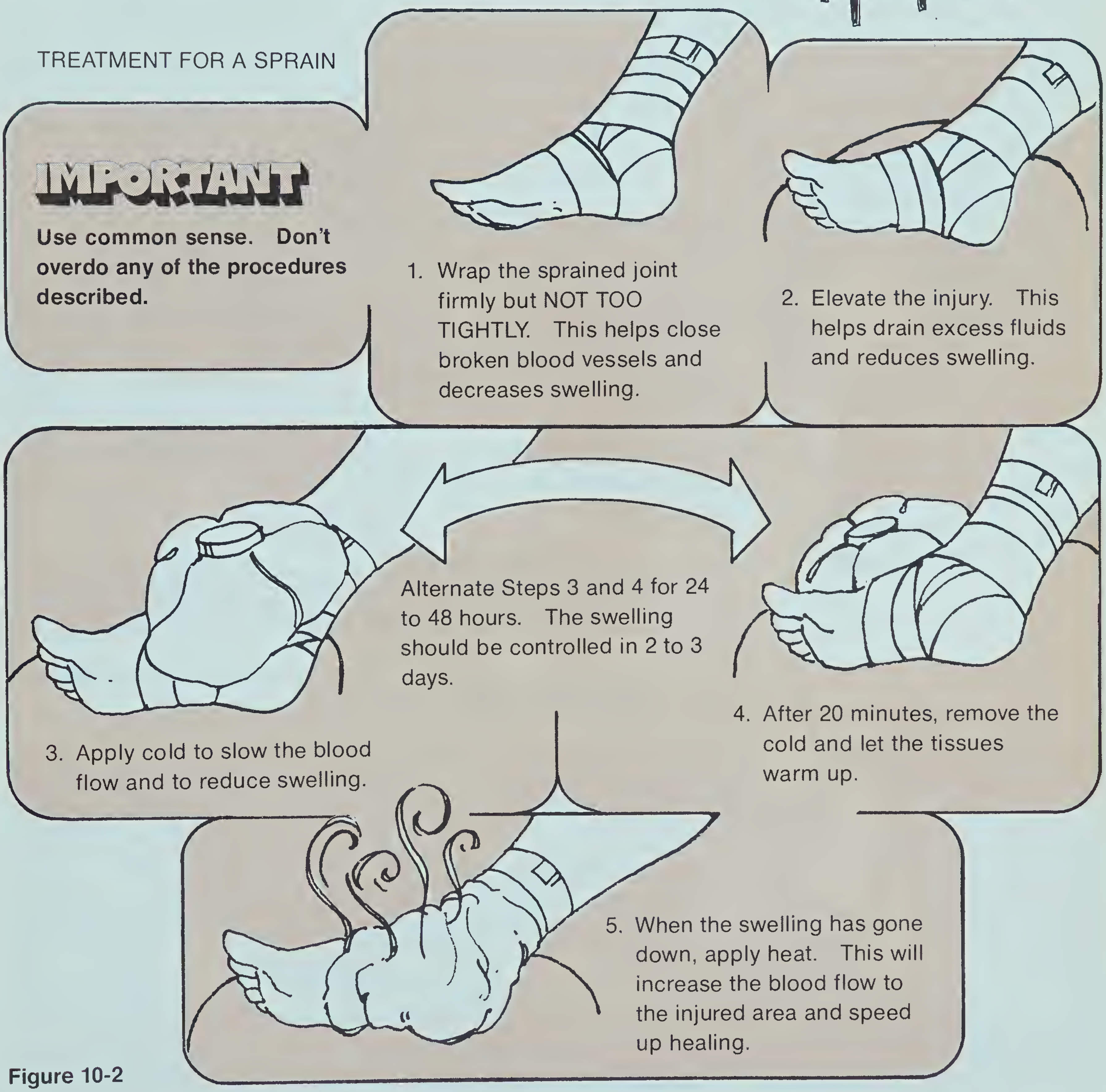


Figure 10-2

10-3. The cold slows the blood flow and reduces swelling. Heat is applied after the swelling goes down—after about 2-3 days of cold applications. If applied too soon, heat would tend to increase swelling.

10-4. To prevent swelling or, if swelling has already occurred, to decrease it.

10-5. Wrap, elevate, apply cold, apply heat.

- 10-3. Suppose you sprained your ankle. Why should you immediately apply cold? Why should you wait two to three days before applying heat?

- 10-4. What is the main reason for wrapping a sprained ankle?

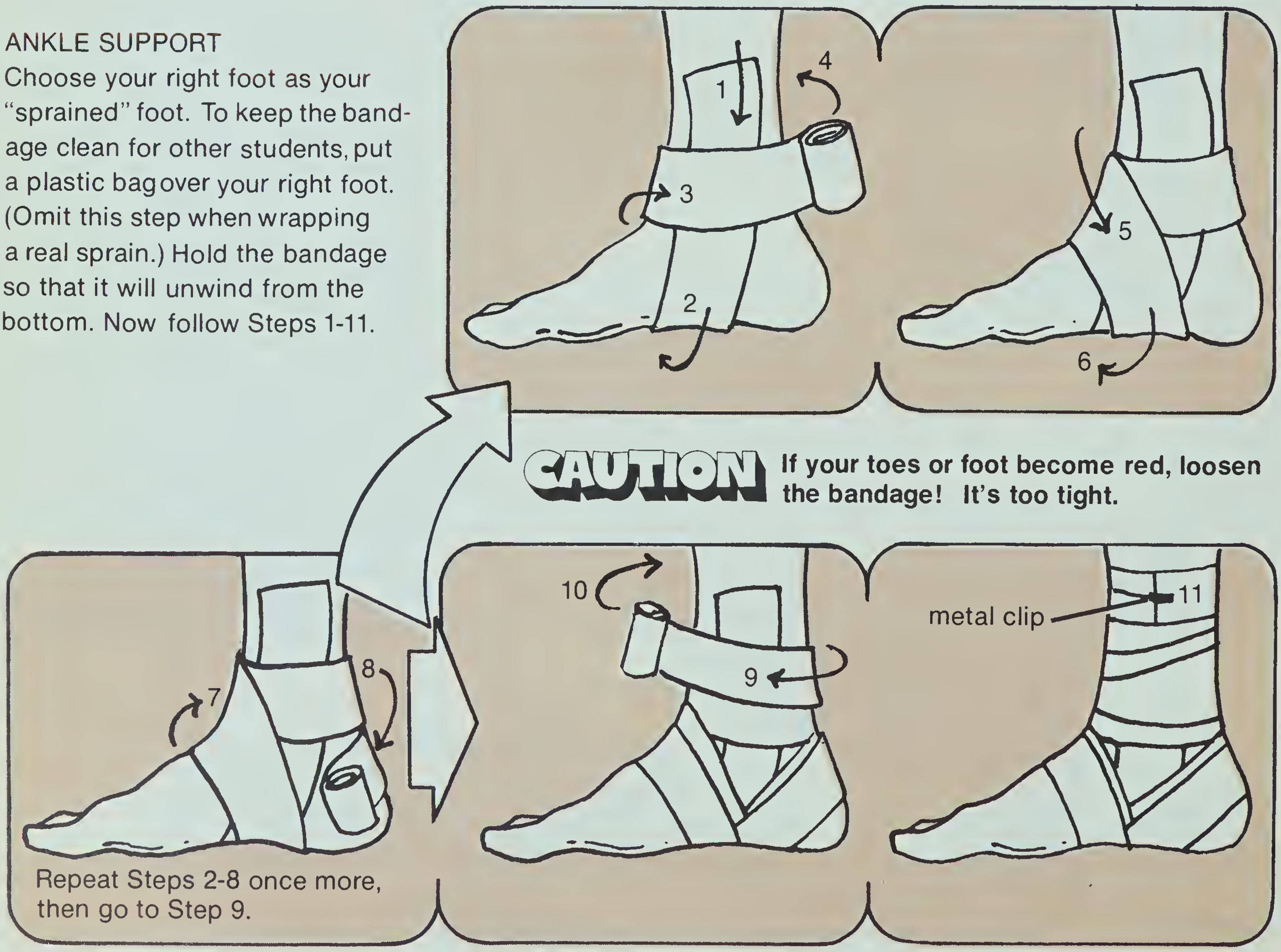
★ **10-5. Write the following steps in the order they should be used for treating a sprain: apply cold; wrap; apply heat; elevate.**

While the damaged tissues are healing, a sprained joint should be protected from further twisting. Extra support is often necessary. Suppose you were recovering from a sprained ankle. Do you know how to bandage your ankle to provide extra support? To find out, get the following materials:

The use of the plastic bag over the foot is for sanitary reasons.

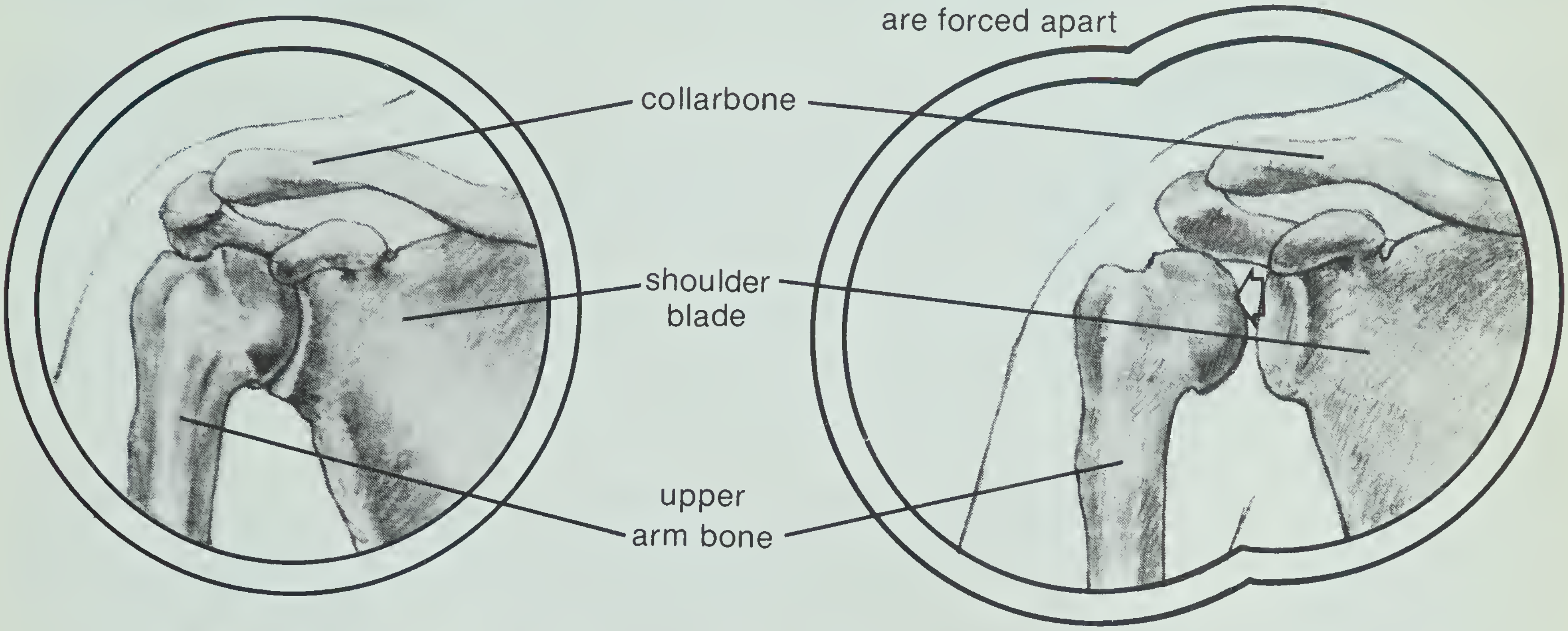
elastic bandage, about 5 cm wide
plastic bag, large enough to fit on your foot

ANKLE SUPPORT
Choose your right foot as your "sprained" foot. To keep the bandage clean for other students, put a plastic bag over your right foot. (Omit this step when wrapping a real sprain.) Hold the bandage so that it will unwind from the bottom. Now follow Steps 1-11.



DISLOCATIONS

A dislocation of a joint happens when the end of a bone is pushed out of place. This injury often occurs during an athletic game. Finger, thumb, and shoulder joints are most often dislocated. A dislocated joint will hurt, swell, and you'll be unable to use it.



★ **10-6. What happens to a joint when it becomes dislocated? What symptoms might help you recognize a dislocation?**

10-6. The two bones which are normally joined together are forced apart. Symptoms might be a lot of pain, lack of use, and swelling of the joint.

If you dislocate your shoulder, don't try to pop the bone back in place by yourself. Why not? The best answer is another question. Who knows best how to reposition the bones without further injuring the tendons and nerves?

★ **10-7. Suppose you tried to reposition a dislocated bone yourself. What might happen?**

10-7. You might cause further injury to nerves and tendons close to the joint.

Suppose you dislocated your shoulder. There are two things you can do before heading for the doctor's office. Put your arm in a sling to keep it from moving. Then apply a cold pack to the shoulder to help control the swelling. Remove the cold pack every 20 minutes to let the tissues warm up. Then apply the cold pack again.

- 10-8. Suppose you dislocated your thumb joint. How does elevating the injured joint help?

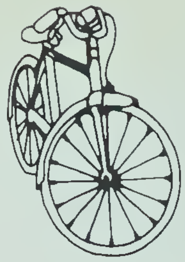
10-8. It helps to reduce swelling.

- 10-9. Why should a doctor reposition a dislocated joint?

10-9. A doctor is less likely to further injure the joint.

ACTIVITY EMPHASIS: How body structures, especially bones, protect the heart, lungs, brain, and spinal cord from injury.

MATERIALS PER LAB GROUP
See Materials and Equipment, pp. TM 3-4.
See also Advance Preparation, p. TM 6.



Activity 11
Special Protection

The human body is a well-wrapped package. Bones provide protection for some of the body's most important organs. You'll learn how bones protect the heart, lungs, brain, and spinal cord.

HEART AND LUNGS

Put your hand on your chest. Can you feel your heart beating? Even though you can feel your heart beating, you can't actually touch it. Your heart and other organs lie behind a protective cage of bones and muscles. (See Figure 11-1.) So if your chest is lightly hit or pushed, your heart won't be injured.

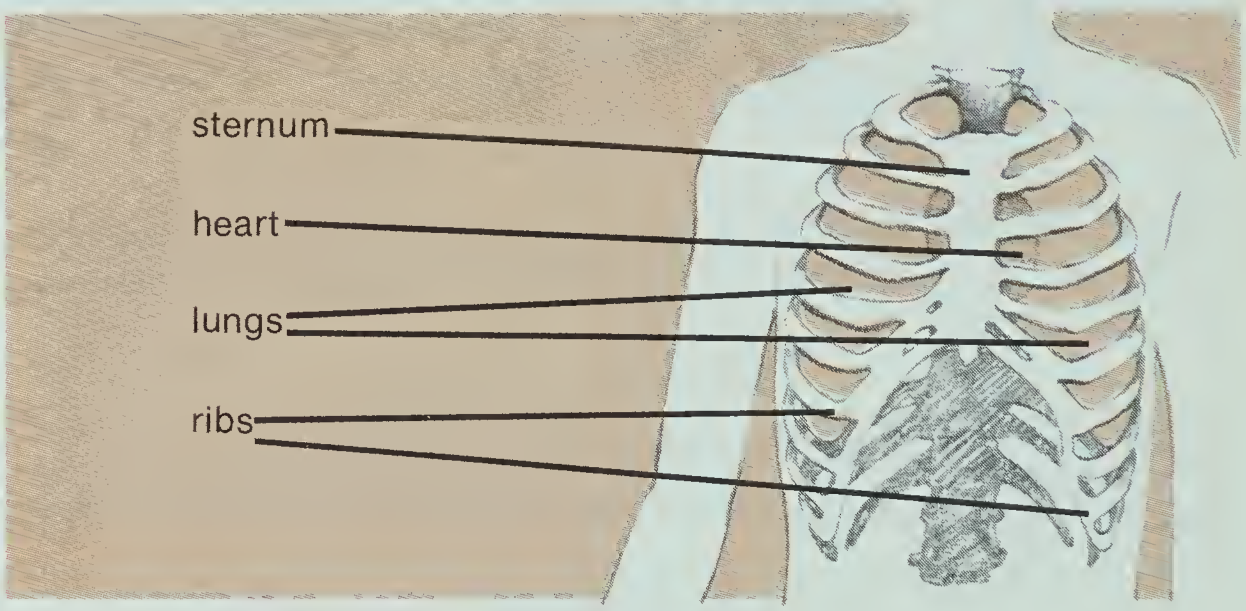


Figure 11-1

11-1. Bones.

• 11-1. What prevents the heart from being injured by a blow to the chest?

11-2. Ribs, sternum.

★ **11-2. Name the bones that protect your heart.**

11-3. Lungs.

★ **11-3. The bones that protect your heart also protect another organ. Name that organ.**

Your muscles won't contract without a message from a nerve fiber. And nerve fibers get their messages from the brain or spinal cord. So your brain and spinal cord have to be especially well protected — they control about everything in your body.

THE BRAIN

A hit on the head will hurt. But if the blow is a light one, the brain probably will not be damaged. To find out why, study Figure 11-2. (The head in Figure 11-2 is not drawn to scale — no one is that thick-headed.) Notice the fluid around the brain. This fluid absorbs most of the impact of light blows and prevents the brain from striking the skull. However, when the force of the blow is great, the watery cushion may not be adequate. The brain may hit the skull.

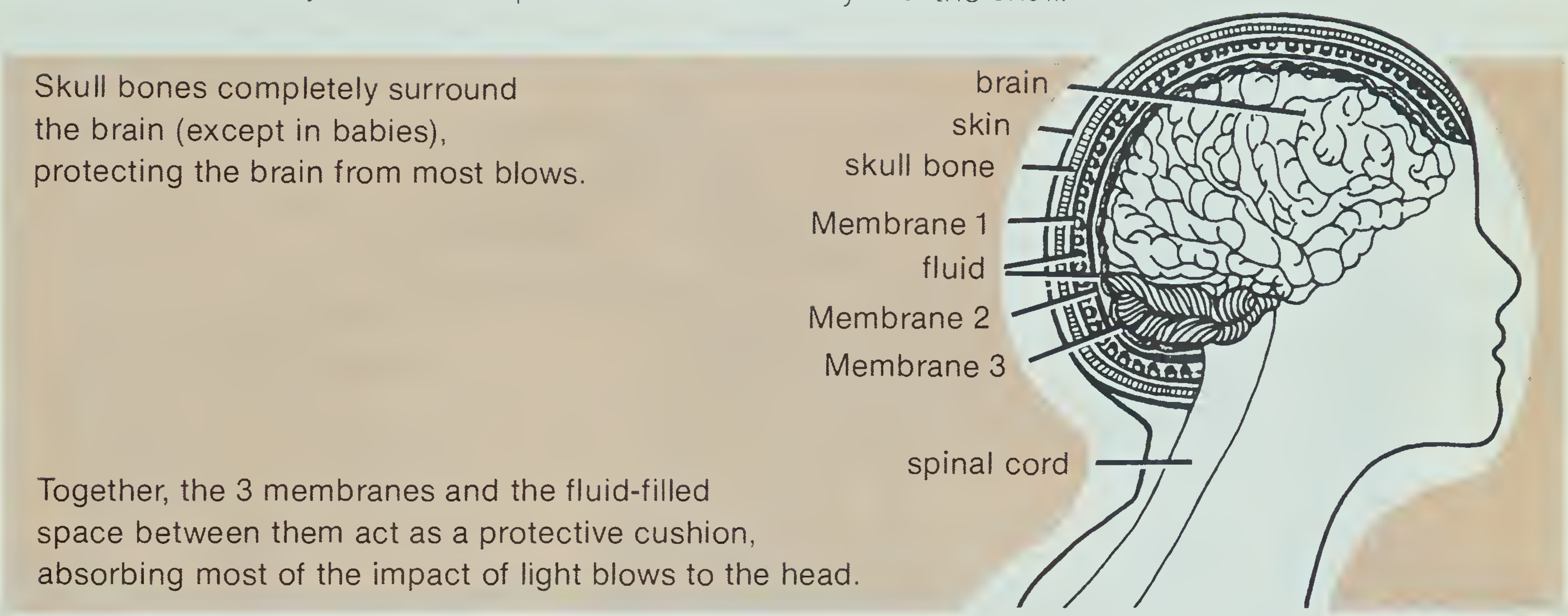


Figure 11-2

To see how the cushion of fluid around the brain works, get the following items:

Brain Jug
modeling clay

The clay may not be needed, but get some just in case it is. Now follow these directions:

Hold the jar upside down with one hand. If there are any leaks, seal them with clay. (Don't touch the seal on the cover of the jar.) Gently tap the side of the jar.

See Advance Preparation, p. TM 7, for directions on how to prepare the brain jug.

How closely the "Brain Jug" approximates the arrangement in the skull depends on the correspondence between the sizes of the jar and the block or ball. For a close approximation, the block should "just fit" inside the jar.

- 11-4. What happened when you tapped the side of the jar? What would happen if you struck the jar harder? (Try it and see, but don't break the jar.)

11-4. Students probably will get these results: when the jar was gently tapped, the block or ball did not touch the side of the jar; when the jar was struck harder, the block or ball touched the jar.

★ **11-5. Describe how the brain is protected from injury.**

11-5. The fluid surrounding the brain absorbs most of the impact of light blows to the head.

THE SPINAL CORD

The spinal cord is a long slender cord extending down your back from your brain. This cord could be easily damaged if it were not well protected. Like the brain, the spinal cord is protected by more than just bone. (See Figure 11-3.)

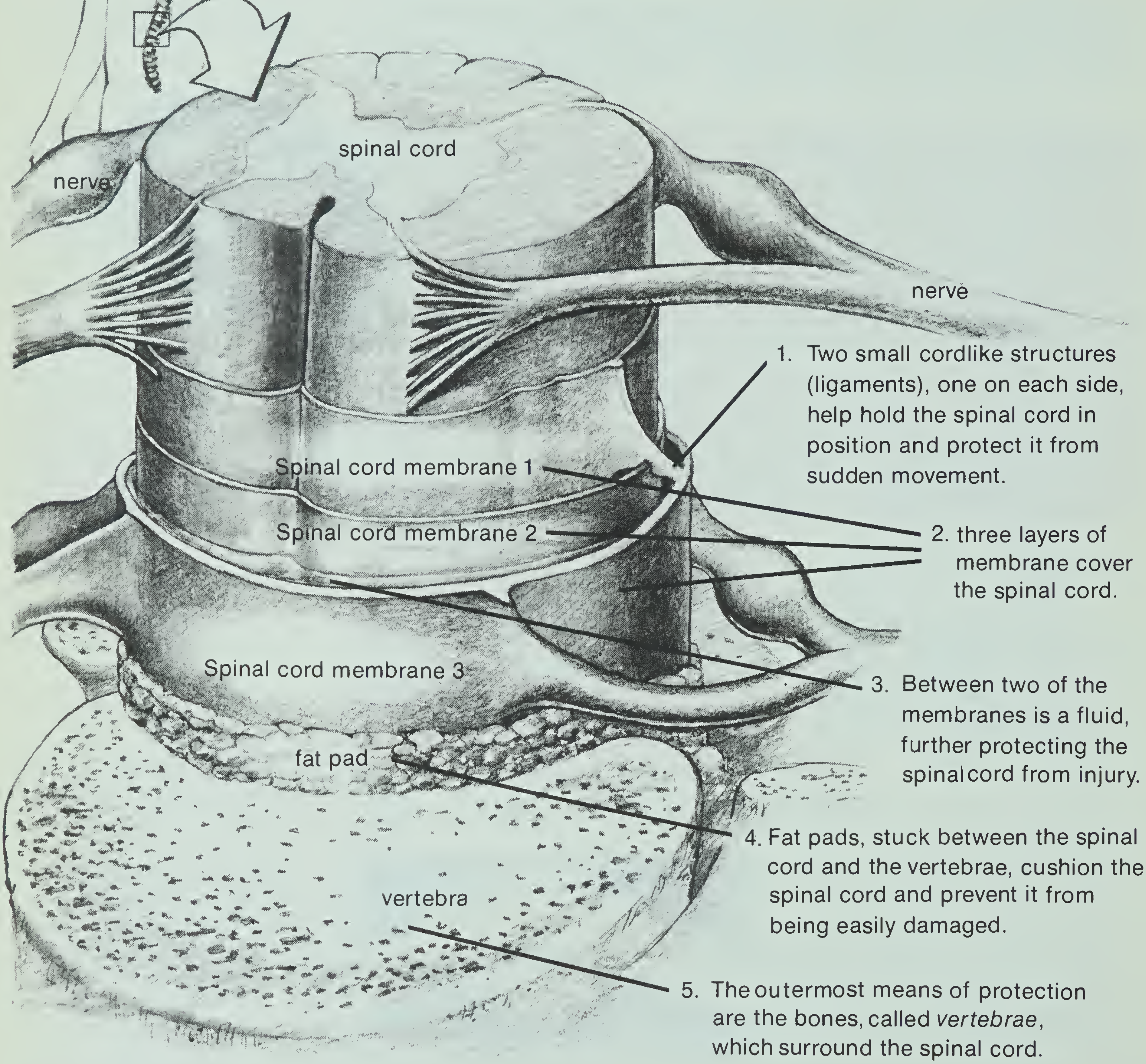


Figure 11-3

Figure 11-3 shows a cross section of a spinal cord. Study the illustration to find the structures that protect the spinal cord.

11-6. Bones, membranes, fluid, ligaments, fat pads.

★ **11-6. List 5 ways that the spinal cord is protected from injury.**

Activity 12
Facts and Fables

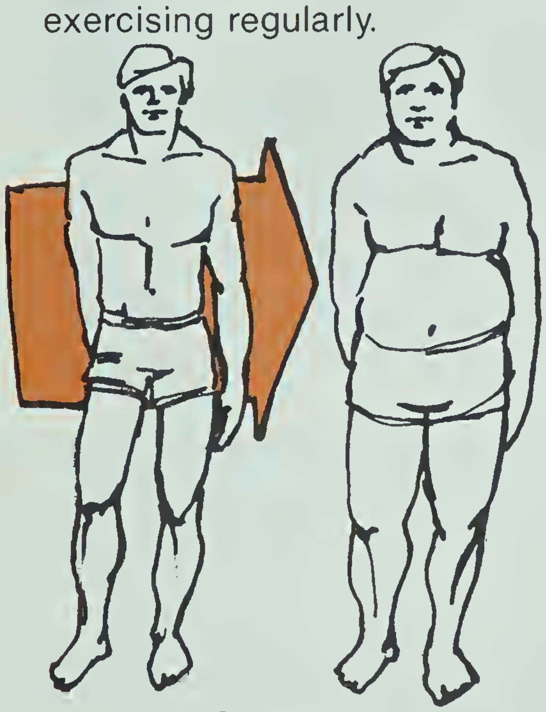
ACTIVITY EMPHASIS: Some common myths about exercise and the facts for these myths; the importance of obtaining good sources of facts in regard to information about physical exercise.

MATERIALS PER LAB GROUP None.

Many people think they know all about exercises. (Talk to any weekend athlete or professional spectator.) Sometimes they *do* know what they're talking about. However, there are many wrong ideas about exercise. It's best to find out the facts and not believe everything you hear. Then you'll know what's really correct.

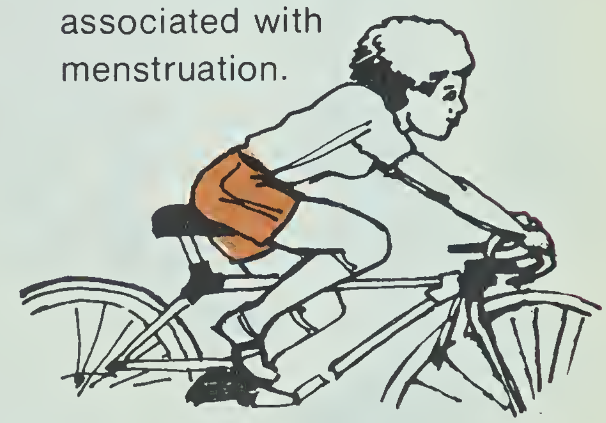
Read the following ten statements about exercise (pages 51 and 52). Then write the numbers from 1 to 10 in your notebook. After each number, write *fact* or *fable* depending on the truth or falsity of the statement.

1. *Muscles and Fat* Muscles will turn to fat if you stop exercising regularly.



2. *Athlete's Heart* By exercising regularly, you'll develop an "athlete's heart," and that's bad.

3. *Menstrual Discomfort* Exercising during a menstrual period will increase the discomfort associated with menstruation.



4. *Stomach Cramps* Swimming after eating will cause muscle cramps and drowning.

5. *Quick Energy* Eating a candy bar before a game will give you extra energy for the game.

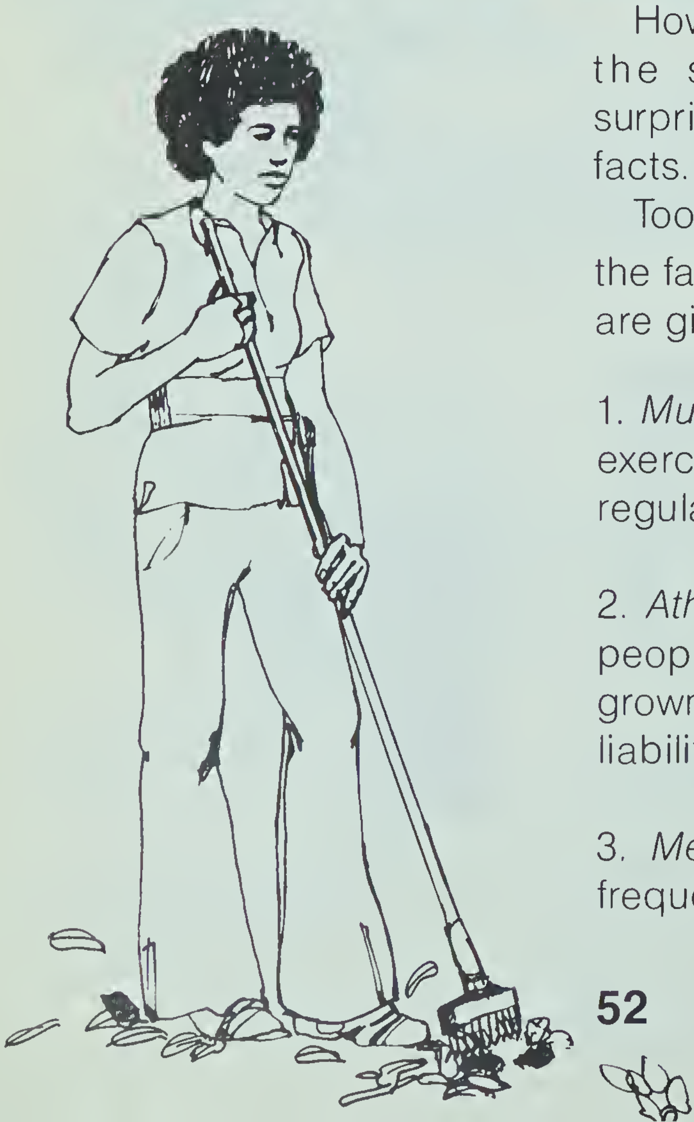
6. *No Fluids* Avoid drinking liquids while you're exercising.

7. *Sweat if off* A good way to keep weight off is by sweating.

8. *Everyone Should Exercise* Without exception, everyone should partake in a vigorous exercise program.

10. *Bulging Muscles* Women who exercise regularly will develop bulging muscles.

9. *Strong Muscles* Extra protein makes you get strong quickly.



How did you do in distinguishing fact from fable? If you said all the statements were fables, you were right! Are you surprised? Many people believe that some of these statements are facts.

Too often people accept information without taking time to check the facts. Let's take another look at the fables. This time the facts are given.

1. *Muscles and Fat* Although many people get fat when they stop exercising, muscles don't turn to fat. Muscles will get smaller when regular exercising stops, but this has nothing to do with fat.

2. *Athlete's Heart* It's true that athletes develop larger hearts than people who don't exercise. But that's not bad. A heart that has grown larger and stronger as a result of exercise is an asset, not a liability.

3. *Menstrual Discomfort* Many women report that light exercise frequently relieves some discomfort during menstruation.

4. *Stomach Cramps* If you swim after eating, you may get a "stitch" or pain in your side. But that pain is not the traditionally feared cramp that causes drownings. Drownings usually occur when people over exert themselves, get muscle cramps, and then panic.

5. *Quick Energy* The food you eat shortly before a game won't get to your muscles to supply energy for that game. The energy that's already stored in your muscles will be used.

6. *No Fluids* Nothing could be more incorrect! Your body loses fluid when you sweat. When there's less fluid in your body, there's an extra strain on your heart. You must replace the fluid by drinking liquids.

7. *Sweat it off* Heavy sweating will cause a rapid weight loss. But drink some water, and you'll gain the weight back. Losing too much water from your body can put a strain on your heart.

8. *Everyone Should Exercise* Most people should exercise. But for some people, even people your age, exercise may be dangerous. Bad hearts and other serious medical problems make it unsafe for some people to do vigorous exercise.

9. *Strong Muscles* Many athletes believe that they need "extra" protein. In fact, they follow special diets. But a normal diet that includes animal and vegetable protein supplies your body with all the protein it needs. Your body can't *use* the "extra" protein.

10. *Bulging Muscles* Most women who exercise regularly do not develop bulging muscles. In fact, exercising often makes a woman slimmer and more fit.

• 12-1. Name some sources that you would use to check the facts in this statement: Stretching exercises cause pulled muscles. Is the statement a fact or fable?

12-1. Textbooks, encyclopedias, scientific journals, medical journals, etc. Fable.

• 12-2. When should you believe another person's opinions or ideas?

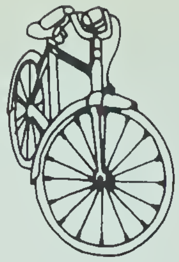
12-2. When facts are presented to support the opinions or ideas.

★ **12-3. For each statement write *fact* or *fable*, depending on the truth or falsity of the statement.**
  a. Exercising regularly will increase the size of your heart.
  b. Exercising may be dangerous for some people.
  c. Women who exercise regularly do not usually develop bulging muscles.
  d. Athletes do not need special diets.

12-3. a. Fact. b. Fact. c. Fact. d. Fact.

ACTIVITY EMPHASIS: Muscle function explained in terms of a feedback system.

MATERIALS PER LAB GROUP See Materials and Equipment, pp. TM 3-4.



Activity 13
Controlling Muscles

When you move your body, you use your muscles. Your muscles contract and relax. The contractions and relaxations are controlled by your brain and spinal cord. Tiny *muscle sensors*, located in your muscles, keep your brain and spinal cord informed about what your muscles are doing. See Figure 13-1.

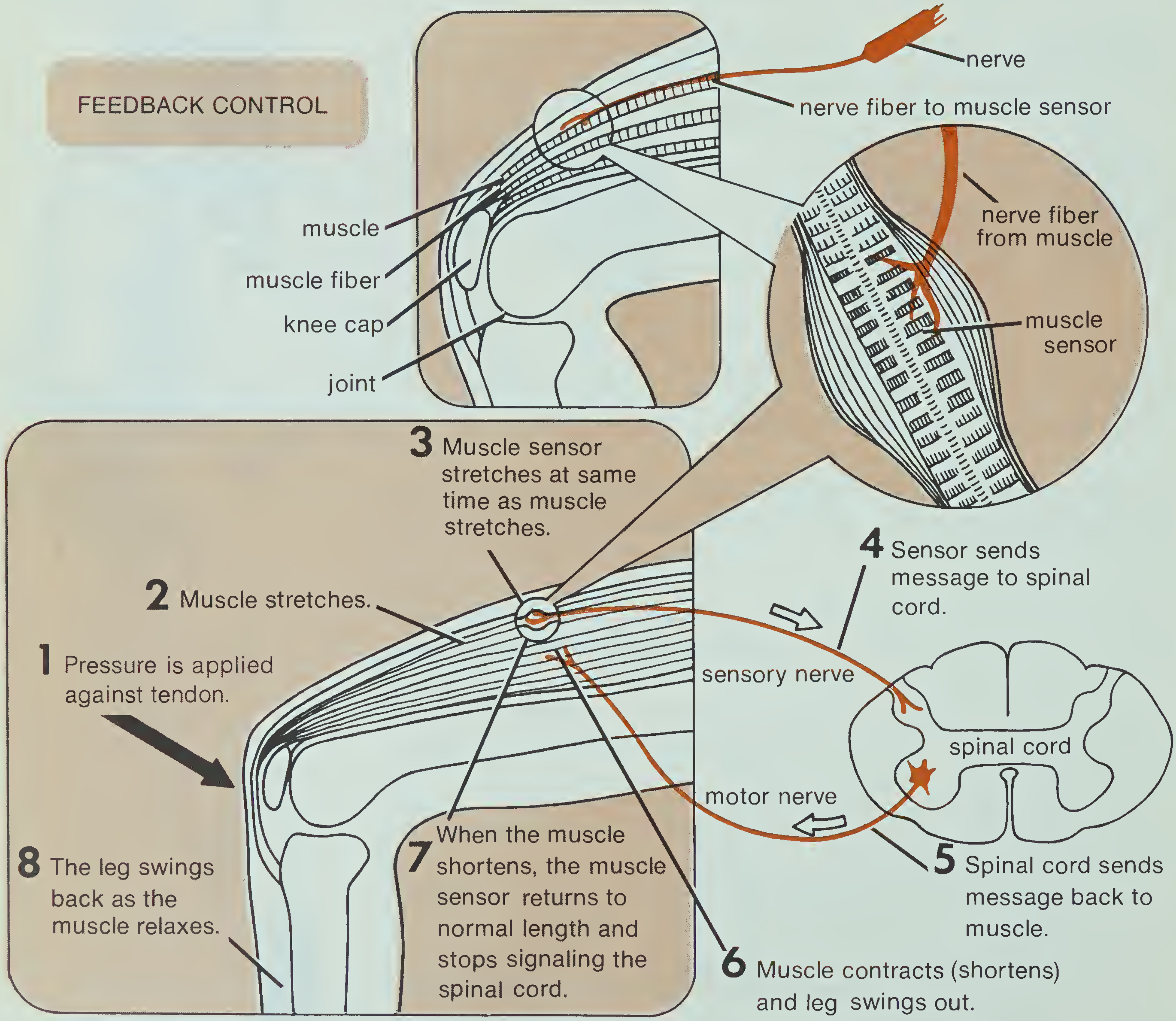


Figure 13-1

A muscle sensor of special interest is one that is sensitive to stretching. That is, when a muscle is stretched, the muscle sensor is also stretched. The sensor signals the spinal cord as to what the muscle is doing. The series of events that takes place is known as *feedback control*. This is illustrated in Figure 13-1. In a feedback control system, a change in one part of the body causes a change in another part.

- 13-1. What activates the muscle sensor in Figure 13-1?

13-1. The stretching of the muscle.

- 13-2. When the signal from the muscle sensor reaches the spinal cord, what happens?

13-2. The spinal cord sends a signal back to the muscle.

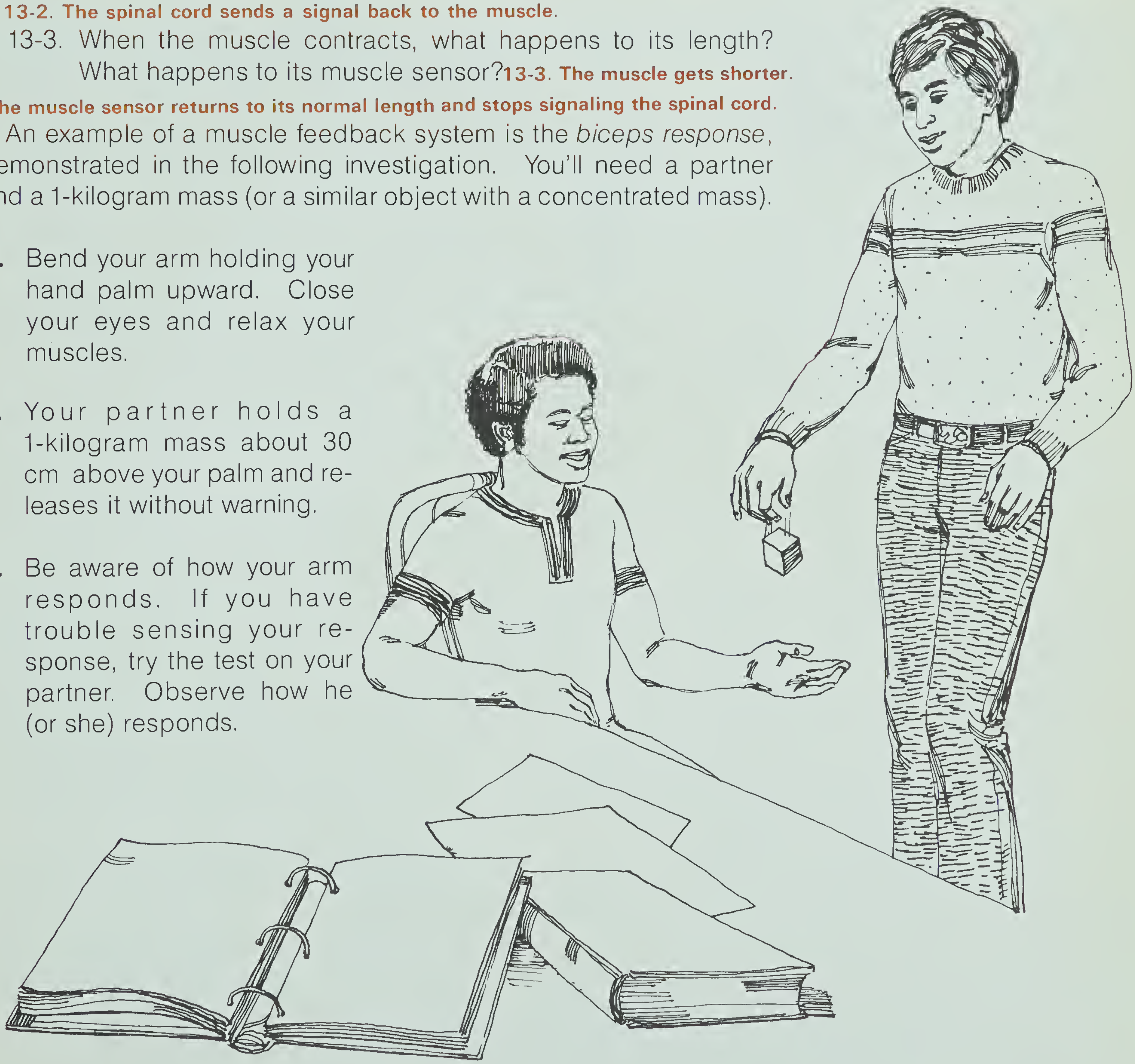
- 13-3. When the muscle contracts, what happens to its length? What happens to its muscle sensor? **13-3. The muscle gets shorter. The muscle sensor returns to its normal length and stops signaling the spinal cord.**

An example of a muscle feedback system is the *biceps response*, demonstrated in the following investigation. You'll need a partner and a 1-kilogram mass (or a similar object with a concentrated mass).

A. Bend your arm holding your hand palm upward. Close your eyes and relax your muscles.

B. Your partner holds a 1-kilogram mass about 30 cm above your palm and releases it without warning.

C. Be aware of how your arm responds. If you have trouble sensing your response, try the test on your partner. Observe how he (or she) responds.



13-4. The arm dropped down.

13-5. The biceps stretched.

- 13-4. When the object hit your hand, how did your arm react?

- 13-5. When the object hit your hand, what happened to your biceps (the muscle at the front of the upper arm).

Figure 13-2 shows how muscle feedback works when the object is dropped in your hand.

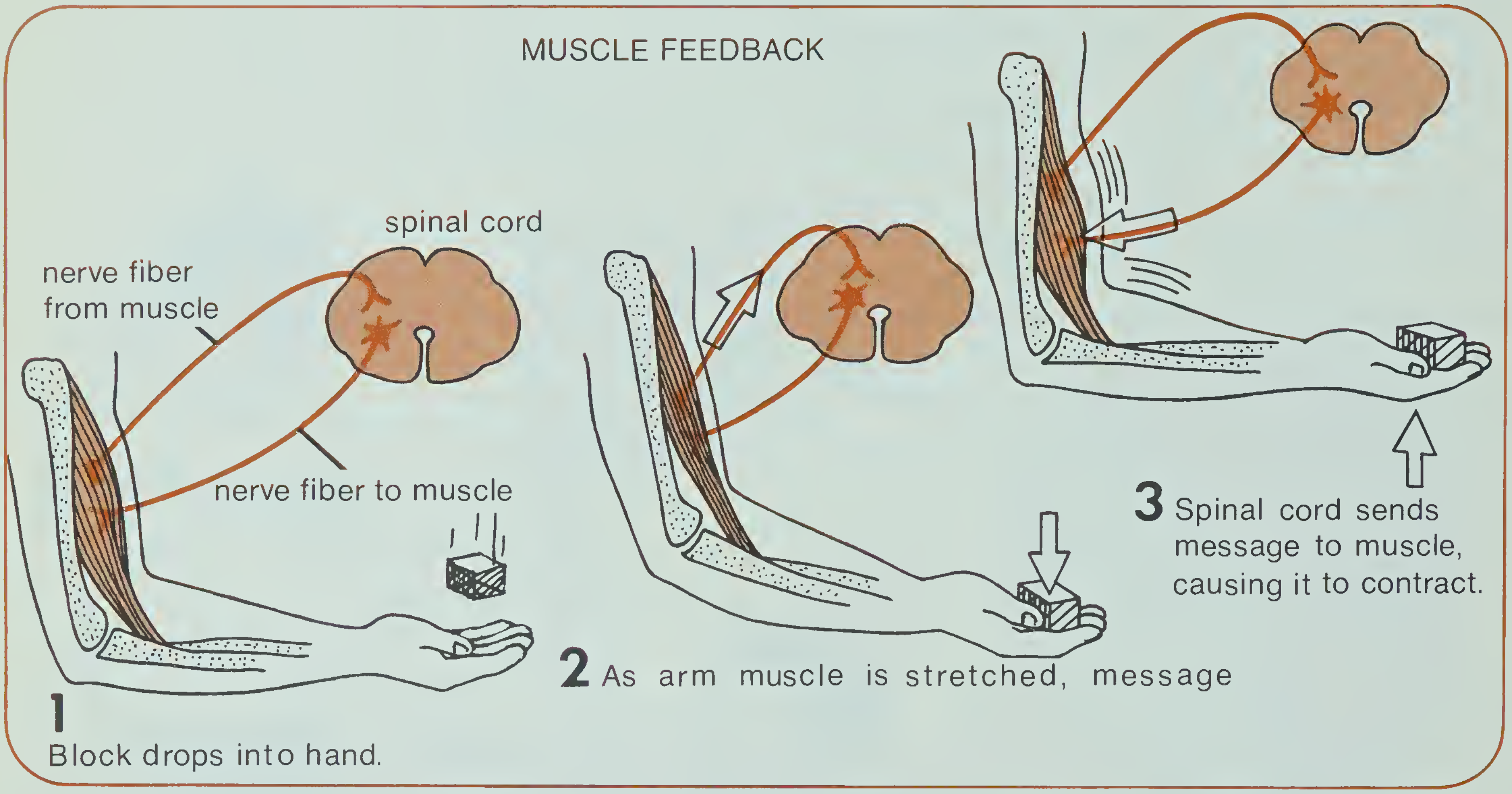


Figure 13-2

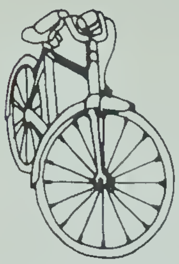
13-6. The muscle stretched causing the arm to drop. When the muscle stretched, the muscle sensor sent a message to the spinal cord. Then the spinal cord sent a message to the muscle causing it to contract. The arm returned to its original position.

- 13-6. Explain why your arm dropped and then quickly returned to its original position. (Refer to Figure 13-2.)

Muscle feedback lets your body rapidly and automatically adjust to changes in muscle length. All physical activities require this feedback. If this is the first time you've run into the idea of feedback, don't worry if the meaning isn't completely clear. You'll see feedbacks again in other minicourses. However, if you've seen them before and you still feel uneasy about them, you may want to look at *Resource Unit 13*. It describes feedback systems in more detail.

13-7. When the muscle sensor is stretched, it sends a message to the spinal cord. The spinal cord sends a message back to the muscle to contract.

★ **13-7. The following explanation of feedback control is false. Rewrite it so that it's true.**
When the muscle sensor is stretched, it sends a message to the muscle to relax. As the muscle relaxes, the muscle sensor relaxes. It sends a message to the muscle to contract.



Activity 14 Advanced Planning

Activity 15 Page 58

Objective 15-1. Analyze the design of an experiment for improving endurance.

Sample Question: Odelia wanted to know which exercise was better for improving endurance: swimming or running. She decided to do an experiment. She tested 30 subjects to measure their endurance. Then she put the subjects into three groups, 10 subjects in each group. One group swam each day for 15 minutes. The second group ran each day for 15 minutes. The third group did not exercise. At the end of six weeks, Odelia again measured the endurance of the subjects.

What is the variable that Odelia controlled in this experiment?

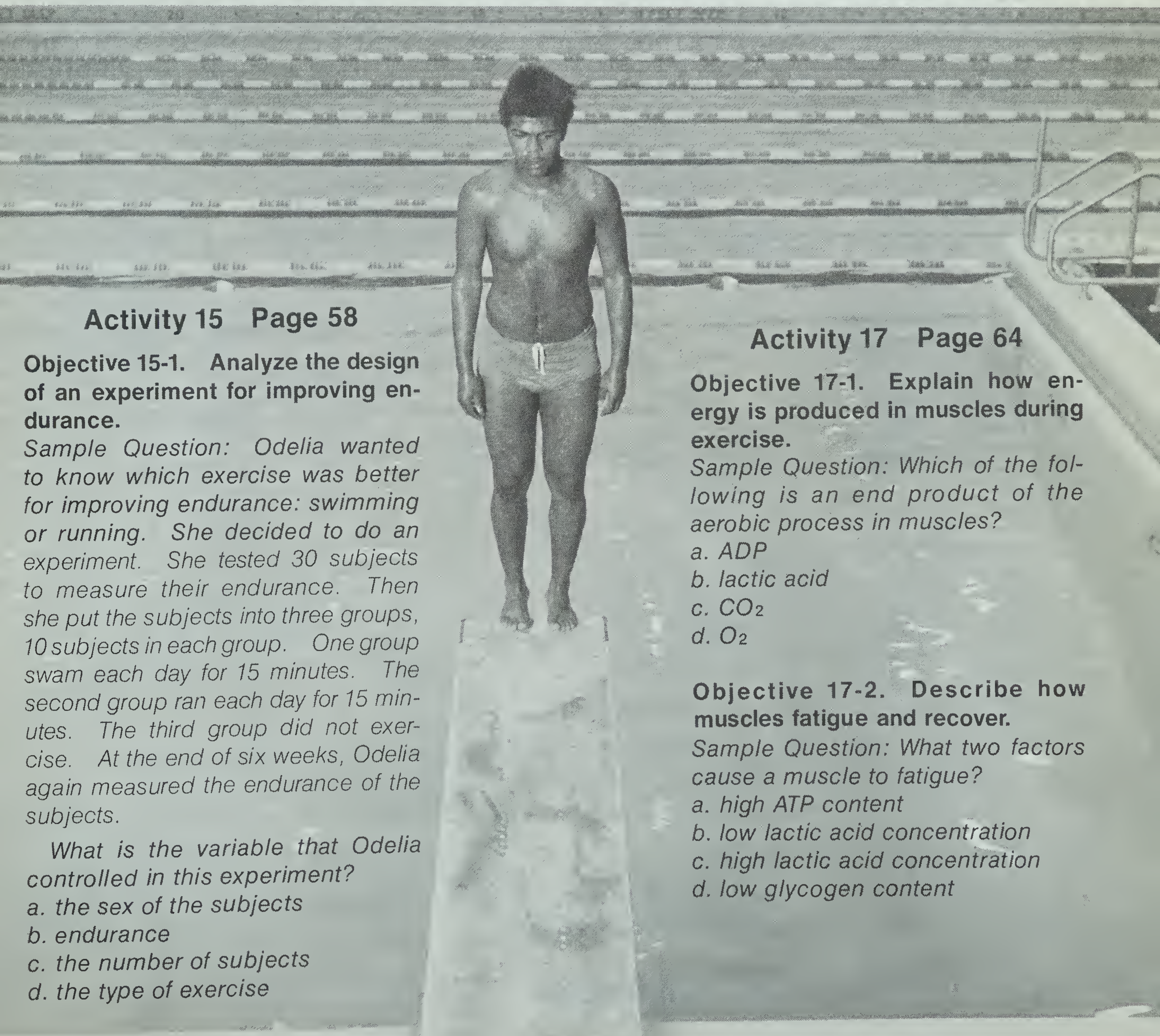
a. the sex of the subjects
b. endurance
c. the number of subjects
d. the type of exercise

Activity 16 Page 60

Objective 16-1. Describe the Sliding-Filament Theory of muscular contraction.

Sample Question: What happens to the dark bands in muscle fibers when a muscle contracts?

a. they get thicker
b. they get thinner
c. they don't change
d. they get lighter



Activity 17 Page 64

Objective 17-1. Explain how energy is produced in muscles during exercise.

Sample Question: Which of the following is an end product of the aerobic process in muscles?

a. ADP
b. lactic acid
c. CO_2
d. O_2

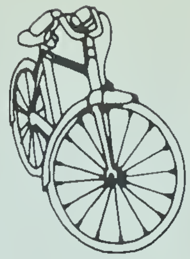
Objective 17-2. Describe how muscles fatigue and recover.

Sample Question: What two factors cause a muscle to fatigue?

a. high ATP content
b. low lactic acid concentration
c. high lactic acid concentration
d. low glycogen content

Answers **15-1** d, **16-1** a, **17-1** c, **17-2** c,d

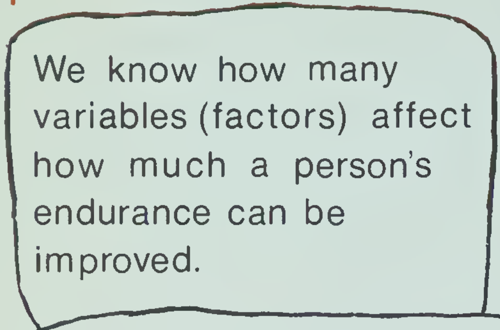
MATERIALS PER LAB GROUP
See Materials and Equipment, pp. TM 3-4.
See also Advance Preparation, p. TM 8.

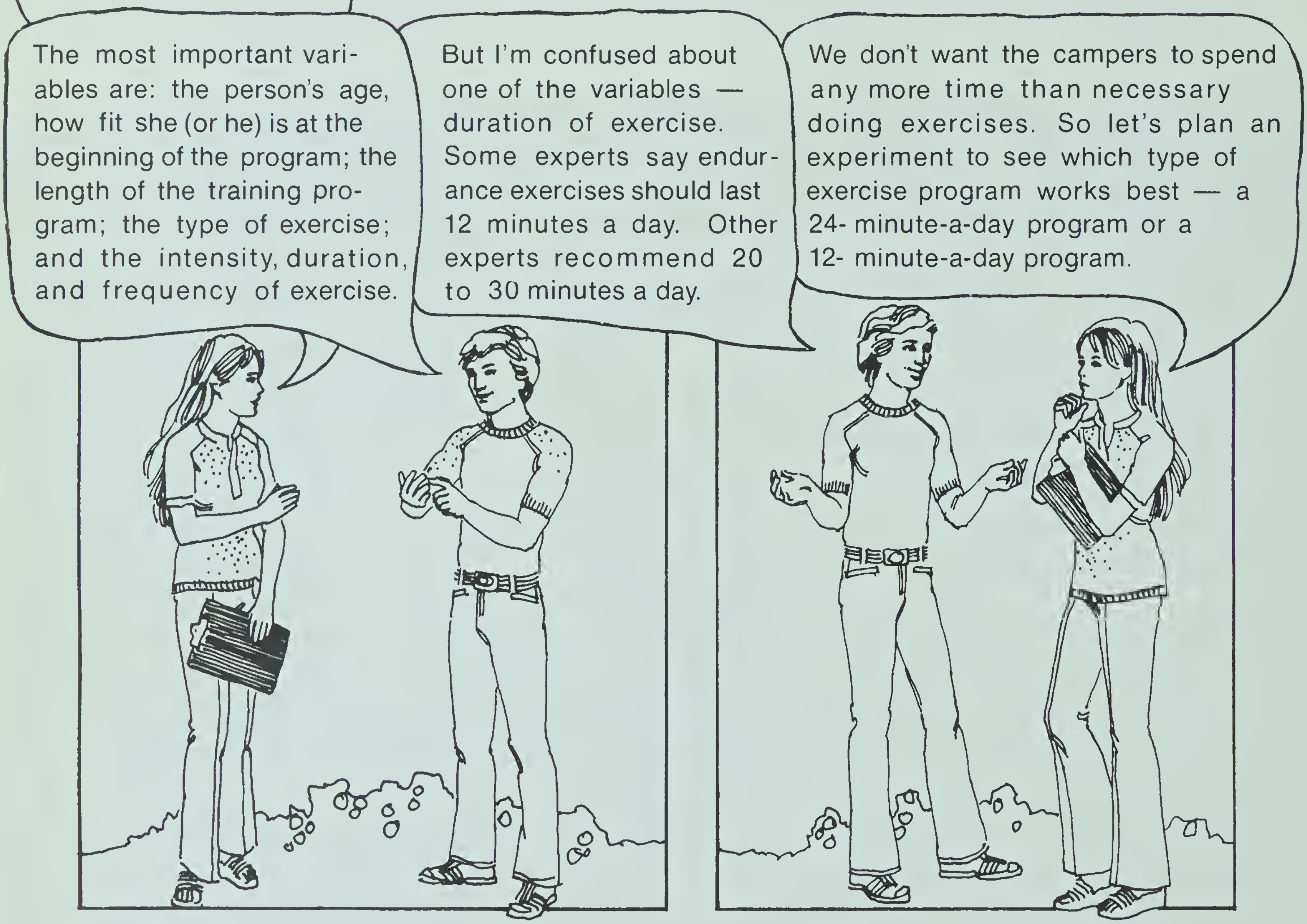


ACTIVITY EMPHASIS: How to design a good experiment and to account for all independent variables.

Activity 15
Solving Problems

Anna and David are physical fitness directors for a summer camp. Their job is to choose an exercise program that will improve the campers' endurance.





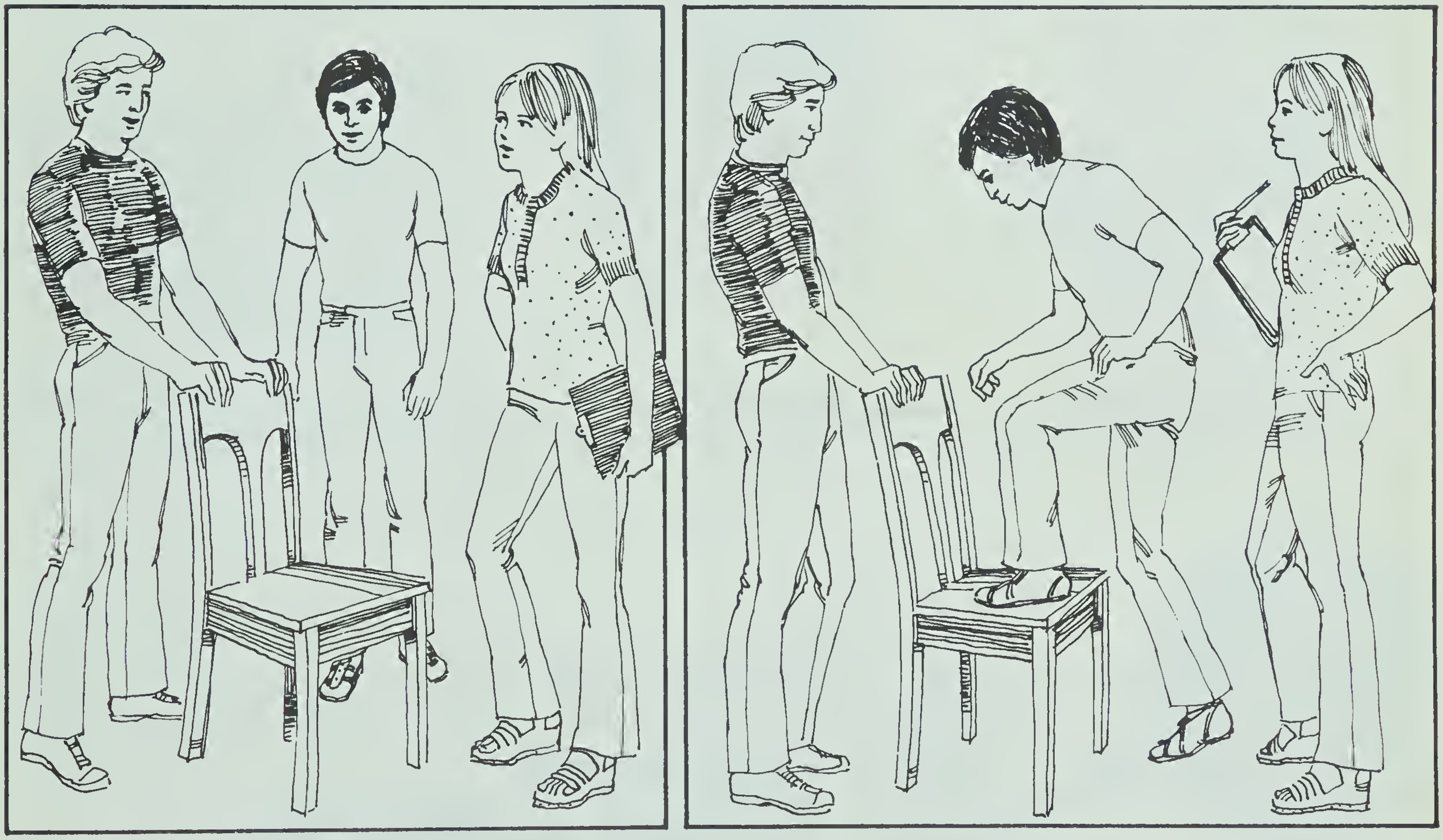
ANNA'S AND DAVID'S EXPERIMENT

Four people took part in the experiment. We'll call these people *subjects*. First they took an endurance test — the Step Test described in Activity 2 of this minicourse. The two subjects with the best endurance were placed in Group A. The other two subjects were placed in Group B.

The subjects in both groups did the same exercises three days a week for two weeks. But those in Group A exercised 12 minutes a day, while those in Group B exercised 24 minutes a day. Anna's and David's hypothesis was this: the endurance of the 24-minutes-a-day group would improve more in two weeks than the endurance of the 12-minutes-a-day group, because when the duration of exercise is increased, endurance is improved.

DATA AND CONCLUSIONS

At the end of two weeks, the four subjects took the endurance test (Step Test) again. To everyone's surprise, the improvement was about the same for both groups. David and Anna concluded that both programs were of equal value. They decided to adopt a 12-minutes-a-day exercise program for the campers.



Get a copy of the *Experiment Analysis Form* to analyze David's and Anna's experiment. If you can't find a copy in the classroom, ask your teacher for one. (Note that the form has two pages.) Answer Question 15-1 through 15-18 on the form. When you finish, continue with this activity. (If you have trouble answering the questions, do *Resource Unit 15*.)

The *Experiment Analysis Form*, supplied separately, is needed for this activity. Be sure to have enough copies available of both pages of the form.

For answers to Questions 15-1 through 15-18, refer to the spirit duplicating master, *Experiment Analysis Form.*

15-19. a

★ 15-19. Which of the following statements are *true* for David's and Anna's experiment?

a. The hypothesis was stated clearly and it identified the variables to be studied in the experiment.
b. The experimenters adequately controlled all identifiable variables in the study.
c. A control group was established to act as a comparison group for the experimental group(s).
d. The experimenters correctly measured the variables.
e. The experimenters provided enough subjects to adequately test the hypothesis.
f. The experimenters correctly assigned the subjects to the experimental and control groups.
g. The conclusions drawn by the experimenters were valid (justifiable).

15-20. a-2, b-1

★ 15-20. Match each group with its description.

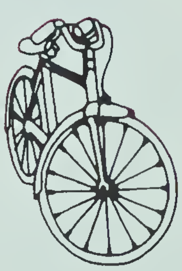
Group	Description
a. experimental group	1. a comparison group that receives no special treatment during the experiment
b. control group	2. a group that receives special treatment during the experiment.

15-21. Because those variables may affect the results and make them difficult to interpret.

★ 15-21. In an experiment, why should you control all the important variables that are not being studied?

ACTIVITY EMPHASIS: Students investigate muscle fibers of grasshoppers or crickets to study the sliding filament theory of muscular contraction.

MATERIALS PER LAB GROUP
See Materials and Equipment, pp. 3-4.
See also Advance Preparation, p. TM 8.



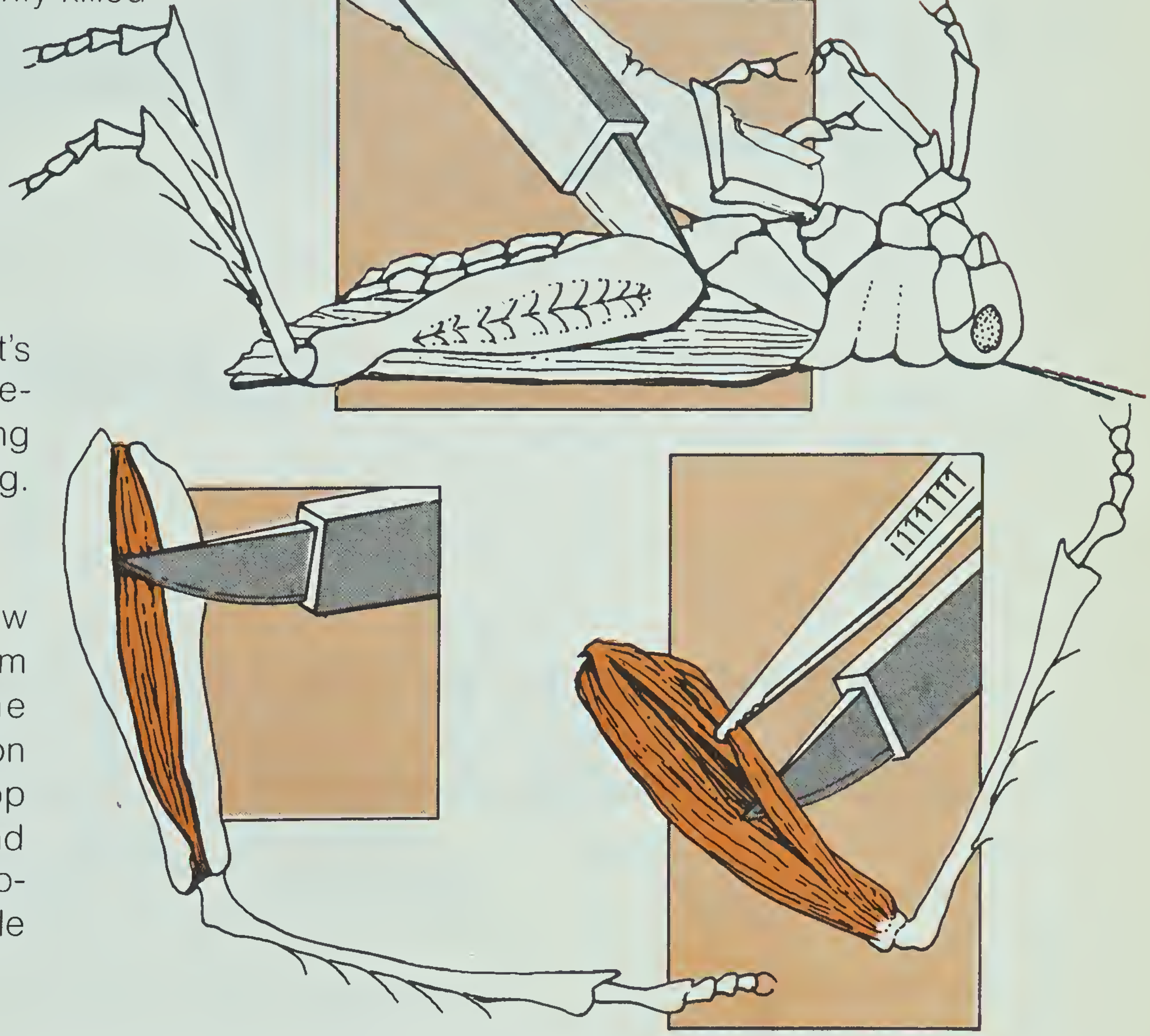
Activity 16
Looking Inside a Muscle

Muscle contraction is one of the key processes in your body. Several theories have been proposed to explain how muscles contract. The *Sliding-Filament Theory* was first proposed by Dr. H. E. Huxley in 1957. This theory has gained general acceptance by scientists.

To develop his theory, Dr. Huxley magnified muscle tissue many times. He studied the muscle fibers in the tissue. You can see muscle fibers that are similar to what Huxley saw during his early investigations. You'll be using a microscope in this investigation. If you don't know how to use one, do *Resource Unit 3* now. Then get the following materials:

Students will get better results with muscle fibers that are fresh and moist. See Advance Preparation, p. TM 8, for killing the grasshoppers or crickets.

grasshopper or cricket, freshly killed
microscope
sharp knife
glass slide
forceps
beaker of water
dropper

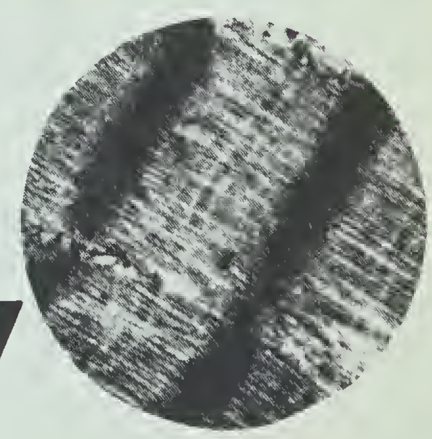


A. Remove one of the insect's large back legs. Then remove the hard outer covering from the thick part of the leg.

B. Using forceps, pull off a few stringy muscle fibers from the large muscle of the leg. Place these fibers on a glass slide. Add a drop of water to the fibers and place the slide on a microscope. Look at the muscle fibers under low power.

• 16-1. In your notebook, draw the muscle fibers that you see under low power. Describe the muscle fibers.

Dr. Huxley wanted to know what caused the light and dark bands in the muscle fibers. To find out, he used an electron microscope which magnified the muscle fibers many thousands of times. Figure 16-1 shows a muscle fiber magnified by an electron microscope.



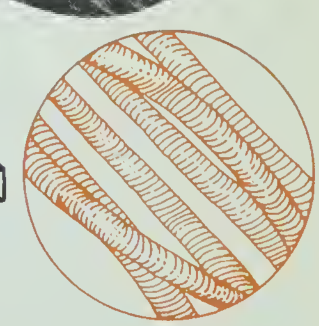


Figure 16-1 16-1. The drawings and descriptions should be of long fibers with dark lines across them.

Muscle fibers have alternating light and dark bands. Figure 16-2 shows what causes the bands. Notice that muscle tissue is made up of muscle fibers; muscle fibers are made up of myofibrils; and myofibrils are made up of myosin and actin filaments.

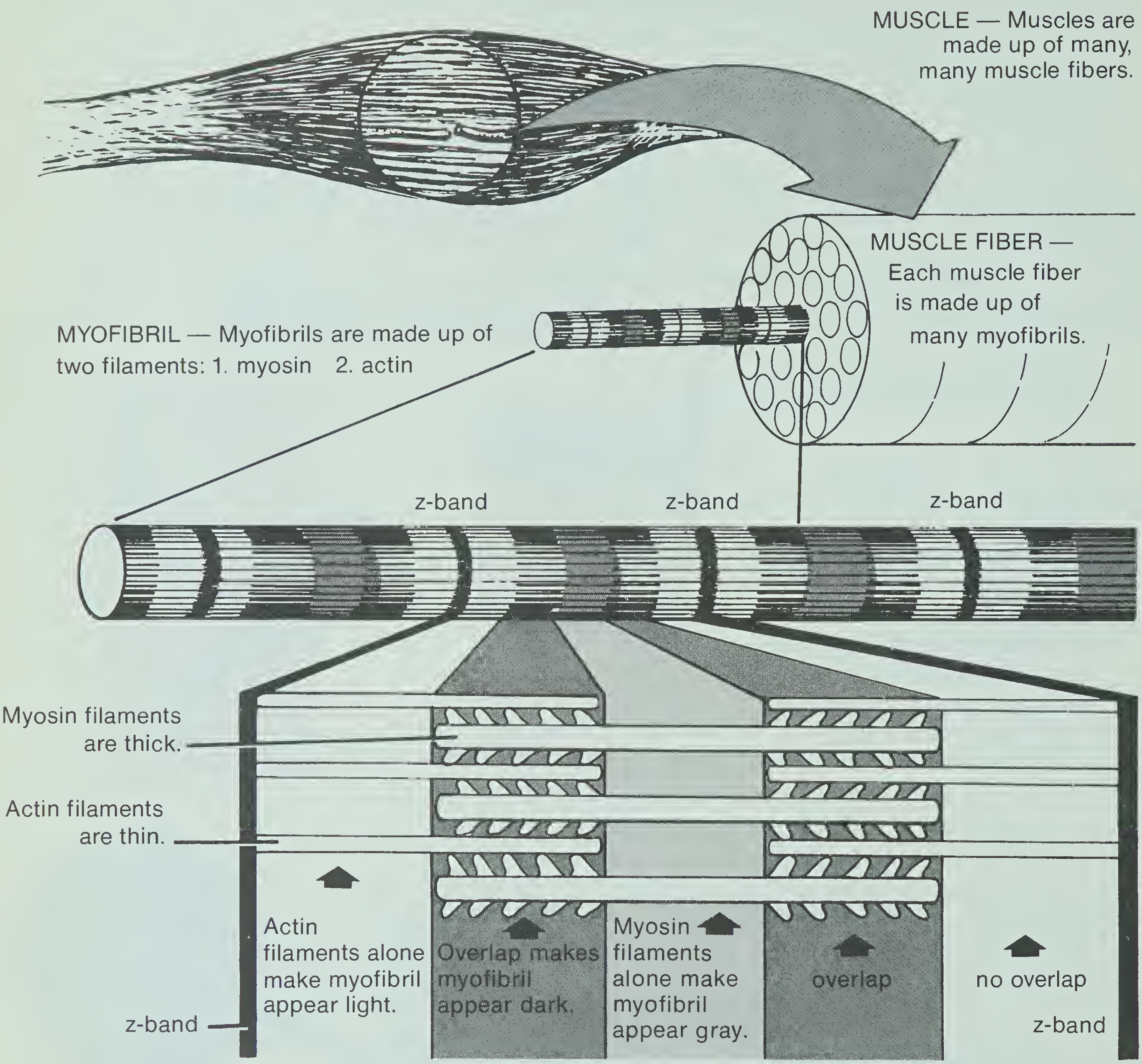


Figure 16-2

- 16-2. What causes the dark bands in muscle fibers?
- 16-3. What causes the light bands in muscle fibers?
- 16-4. In muscle fibers, there are areas that are gray in color. What are these areas?

16-2. Answers may vary. Correct answers are: ***The overlap of thick (myosin) and thin (actin) filaments*** **and/or** ***Z-bands.***

16-3. The actin filaments alone (and not overlapped by the myosin filaments).

16-4. The myosin filaments alone.

Pictures called electron micrographs were taken of the contracted and stretched muscle fibers, magnified by an electron microscope. Dr. Huxley made several important observations from these pictures. His observations are shown in Figure 16-3.

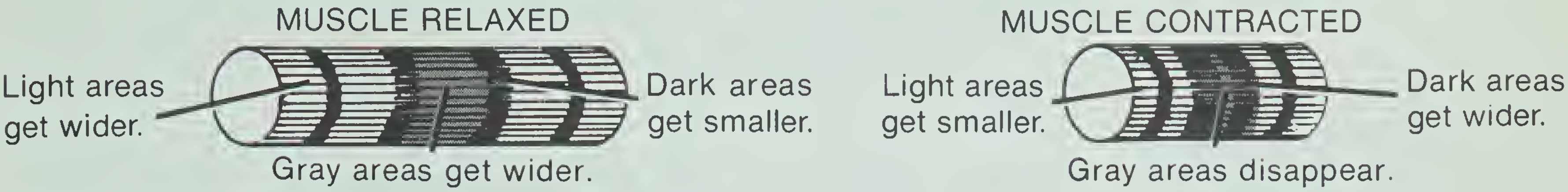


Figure 16-3

• 16-5. What happens to the filaments as a muscle contracts? (Base your answer on Huxley's observations.)

16-5. The filaments move so that there is more overlap.

The conclusions that Huxley made are still considered to be sound today. But the Sliding-Filament Theory only described what happened during a contraction. It did not explain *how* a muscle contracts. More study was needed.

Finally, after much study of electron microscope photos, small projections were observed extending from the myosin filaments. Based on these observations, Huxley proposed an explanation of muscular contraction. This explanation is shown in Figure 16-4.

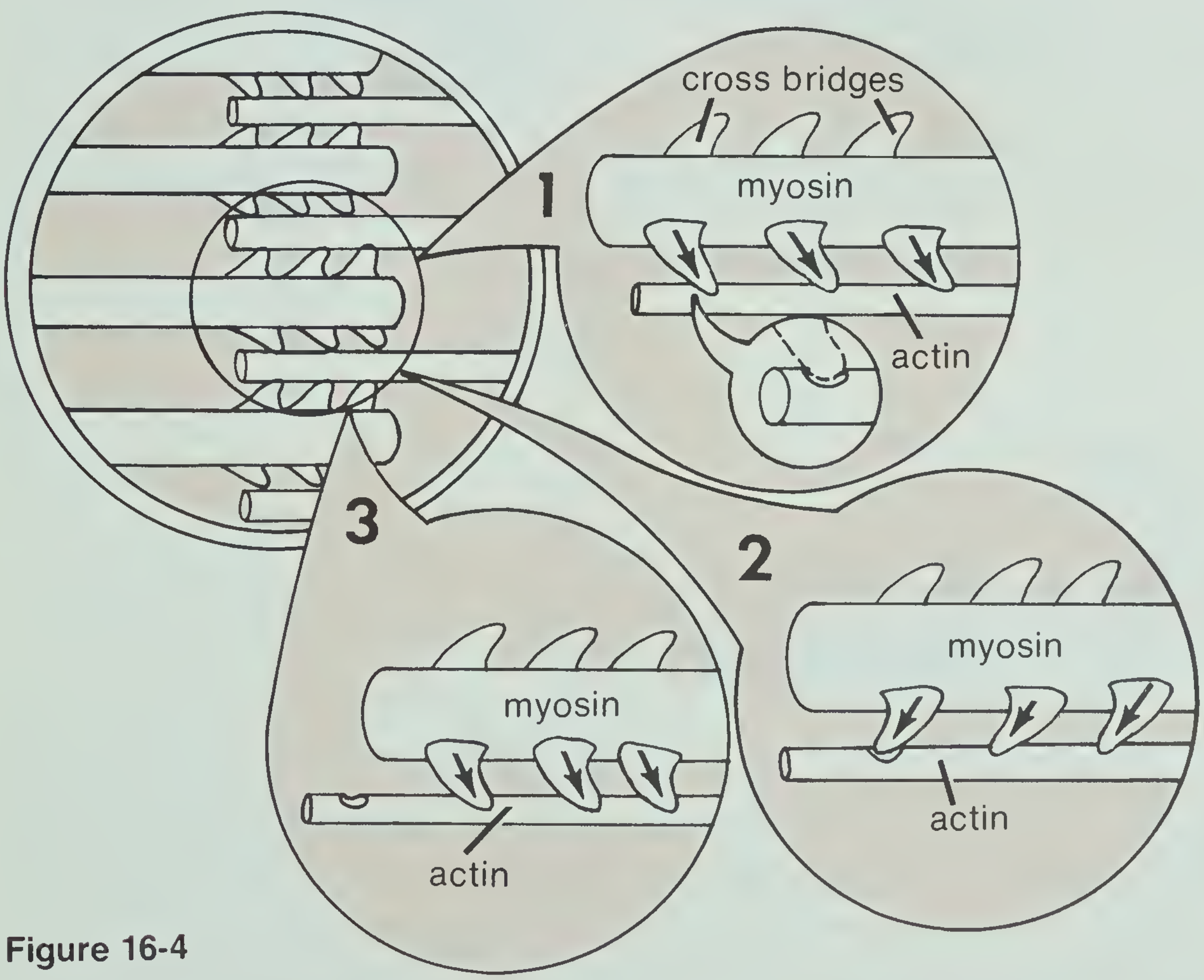


Figure 16-4

MUSCULAR CONTRACTION

1. Cross bridges hook into actin at the connecting site.
2. Cross bridges pull the actin.
3. Cross bridges and actin break connection. Cross bridges bend back and hook onto next connection. Then the cross bridges repeat Steps 2 and 3.

As the actin filaments slide toward each other, the muscle shortens and the body part moves.

★ **16-6. According to Huxley, what is the role of the cross bridges in a muscular contraction?**

16-6. They help to move the filaments toward each other.

The myosin cross bridges don't move by themselves. They need energy to move. The energy comes from a special chemical in the human body. The chemical is called *ATP*. When a nerve stimulates a muscle, ATP is released in the muscle and causes the cross bridges to move.

16-7. Answers may vary. Some correct answers are: *It provides the energy that causes the cross bridges to move* or *It's the energy needed to cause the muscle to contract.*

16-8. It contracts.

16-9. a-2, b-1

16-10. b, a

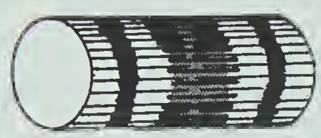
- 16-7. Why is the ATP in muscles important?

- 16-8. When cross bridges move in muscle fibers, what happens to the muscle?

★ **16-9. Match each illustration in List A with its enlargement in List B.**

List A

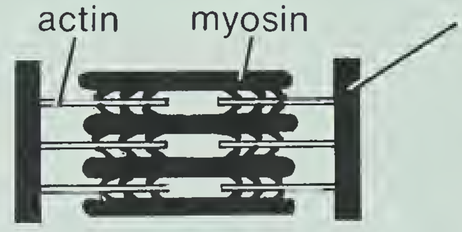
a.



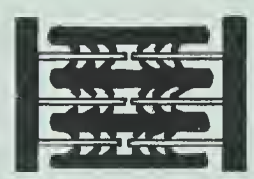
b.

List B

1.



2.



★ **16-10. Look at List A in Question 16-9. Which illustration shows relaxed muscle fibers? Which shows contracted muscle fibers?**

ACTIVITY EMPHASIS: The aerobic and anaerobic processes of producing energy and their effect on muscular fatigue.

MATERIALS PER LAB GROUP
See Materials and Equipment, pp. TM 3-4.

Activity 17
Fatigue

Everyone knows that when you work hard, you become fatigued (tired). Why does this happen? Does your body always get fatigued for the same reason? Or are there several reasons? Both of the following situations produced fatigue.

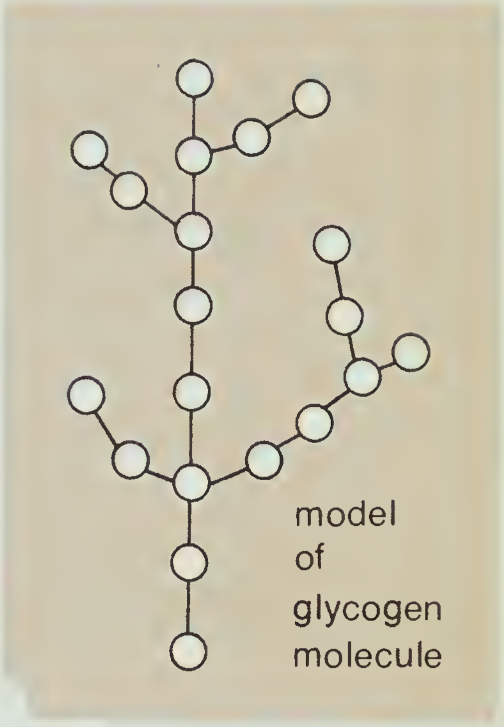
A runner finished an 800-metre race in 2 minutes and 20 seconds. She was exhausted. But she recovered after an hour of rest.

A basketball player played for 60 minutes in a championship game. She was totally worn out but recovered after a day of rest.

Both athletes were very fatigued at the end of the physical activity. Were they fatigued for the same reason? Why did it take more time for the basketball player to recover than for the runner? In order to answer these questions, you need to know how muscles produce energy.

There are two energy-producing processes in muscles — the *anaerobic* (an-ah-ROW-bik) process and the *aerobic* (air-o-bik) process. Both processes start with the breakdown of large carbohydrate (sugar) molecules called *glycogen*. Glycogen is stored in the muscles. Both processes end with the formation of *ATP*, the body's source of energy. ATP is an energy-producing compound that contains stored chemical energy. (*ATP* is the abbreviation for *a*denosine *t*ri*p*hosphate.)

Use Figure 17-1 to follow the anaerobic and aerobic processes. Notice that both processes start with the breakdown of glycogen to pyruvic acid.



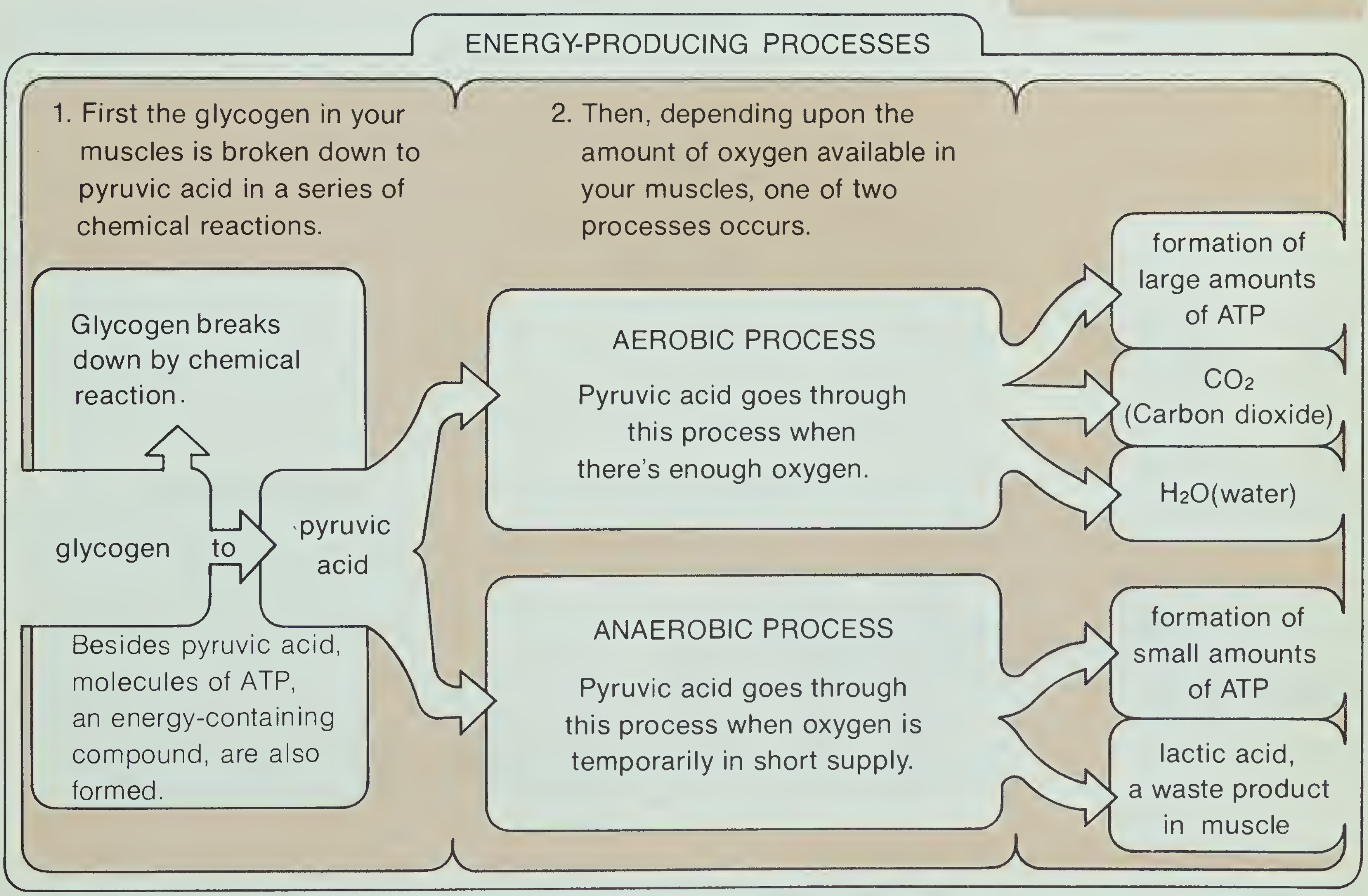


Figure 17-1

17.1 The amount of oxygen available in the muscles.

• 17-1. What condition in muscles determines whether pyruvic acid goes through the anaerobic or aerobic process?

17-2. Lactic acid.

• 17-2. Name the waste product that's formed in muscles when glycogen is broken down without adequate oxygen.

17-3. ATP

★ **17-3. Name the energy-producing compound that's formed during the anaerobic breakdown of glycogen.**

17-4. H_2O, CO_2, and ATP

★ **17-4. What are the three end products from the aerobic breakdown of glycogen?**

Whether glycogen is broken down aerobically or anaerobically, muscles produce ATP. But there is a great difference in the amounts of ATP produced.

The aerobic process produces about 19 times more ATP than the anaerobic process. (Net: 38 ATP vs 2 ATP.)

Your muscles use the anaerobic process only in emergencies — when they need extra energy and they can't get enough oxygen. This situation often occurs in sports activities. In a sprint, for example, your muscles need energy quickly. The only way they can provide the energy is by the anaerobic process.

Study Figure 17-2. The graph shows how much energy is produced by each process during strenuous activities. The activities are of different durations. (If you have trouble reading the graph, do *Resource Unit 2*.)

It's important to note that during strenuous activities, energy is produced by *both* processes. But in most cases, the percentage of energy produced by one process is much greater than the percentage produced by the other process.

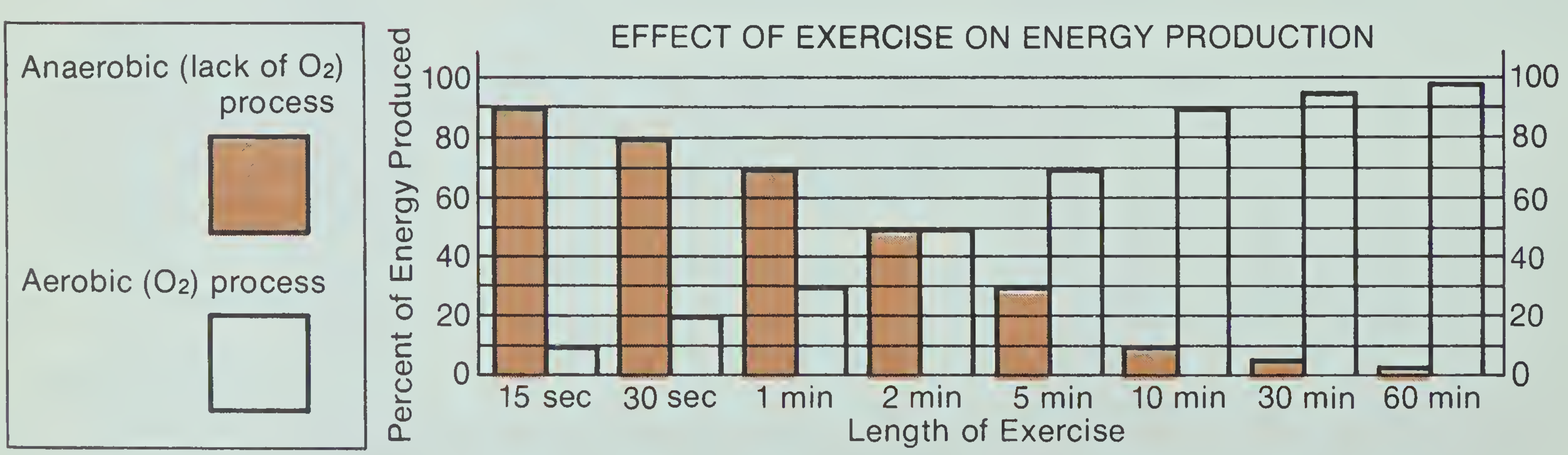


Figure 17-2

17-5. Anaerobic process.

• 17-5. Which process provides more energy for strenuous activities of two minutes or less? (See Figure 17-2).

• 17-6. If a strenuous activity lasts 60 minutes, what percentage of energy is produced by the aerobic process? (See Figure 17-2.)

17-6. About 98%.

ANAEROBIC PROCESS

Your muscles need a lot of energy during short periods of strenuous activity (such as running in an 800-metre race). Most of this energy is produced anaerobically. The lungs, heart, and blood vessels can't deliver enough oxygen for the energy to be produced aerobically.

As energy is produced during the anaerobic process, lactic acid is also produced. If a large concentration of lactic acid builds up in your muscles, your muscles will stop producing energy. As a result, you become fatigued and have to rest.

Look at the graph in Figure 17-3. It shows that the lactic acid concentration in muscles increases during an 800-metre race and decreases after the race. Notice the *resting value* in the graph. This represents the concentration of lactic acid that's usually present in a resting muscle.

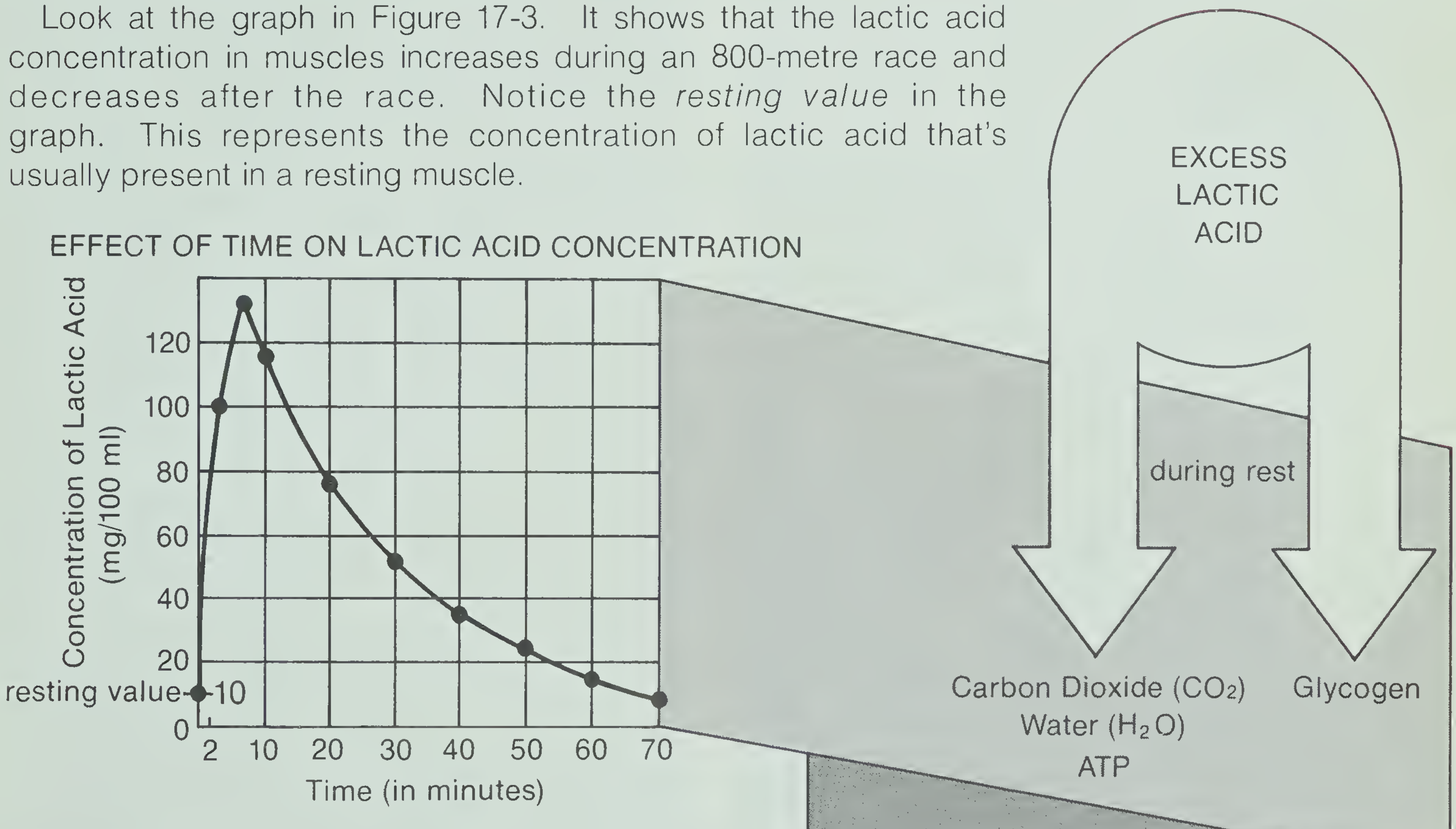


Figure 17-3

• 17-7. How much time did it take for the concentration of lactic acid to return to the resting value?

17-7. About 70 minutes.

• 17-8. Suppose you were watching someone run an 800-metre race. What would be the approximate concentration of lactic acid in *your* muscles?

17-8. About 10 mg/100 ml

In order to fully recover from strenuous exercise, your muscles must get rid of the excess lactic acid. While you rest, your muscle cells slowly uses up some of the lactic acid by converting it to carbon dioxide, water, and ATP. Your liver converts the rest of the excess lactic acid to glycogen.

17-9. I probably wouldn't do as well in the second race because there still would be an excess level of lactic acid in my muscles.

- 17-9. Suppose you ran an 800-metre race, rested for 20 minutes, then ran in another 800-metre race. How do you think you'd do in the second race? Explain your answer.

AEROBIC PROCESS

Your muscles need a lot of energy during long periods of strenuous activity (such as a basketball game).

17-10. Aerobic process.

- 17-10. Look at Figure 17-2 (page 66). Which process produces the most energy for strenuous activities lasting five minutes or longer?

During long-term exercise, most of the energy for your muscles is produced aerobically. Your lungs, heart, and blood vessels can get enough oxygen to your muscles for the aerobic process to take place. Since the exercise lasts a long time, your muscles use a lot of stored glycogen. (See Figure 17-4.) Your endurance during long-term exercise is partly determined by how long it takes for the glycogen to be used up.

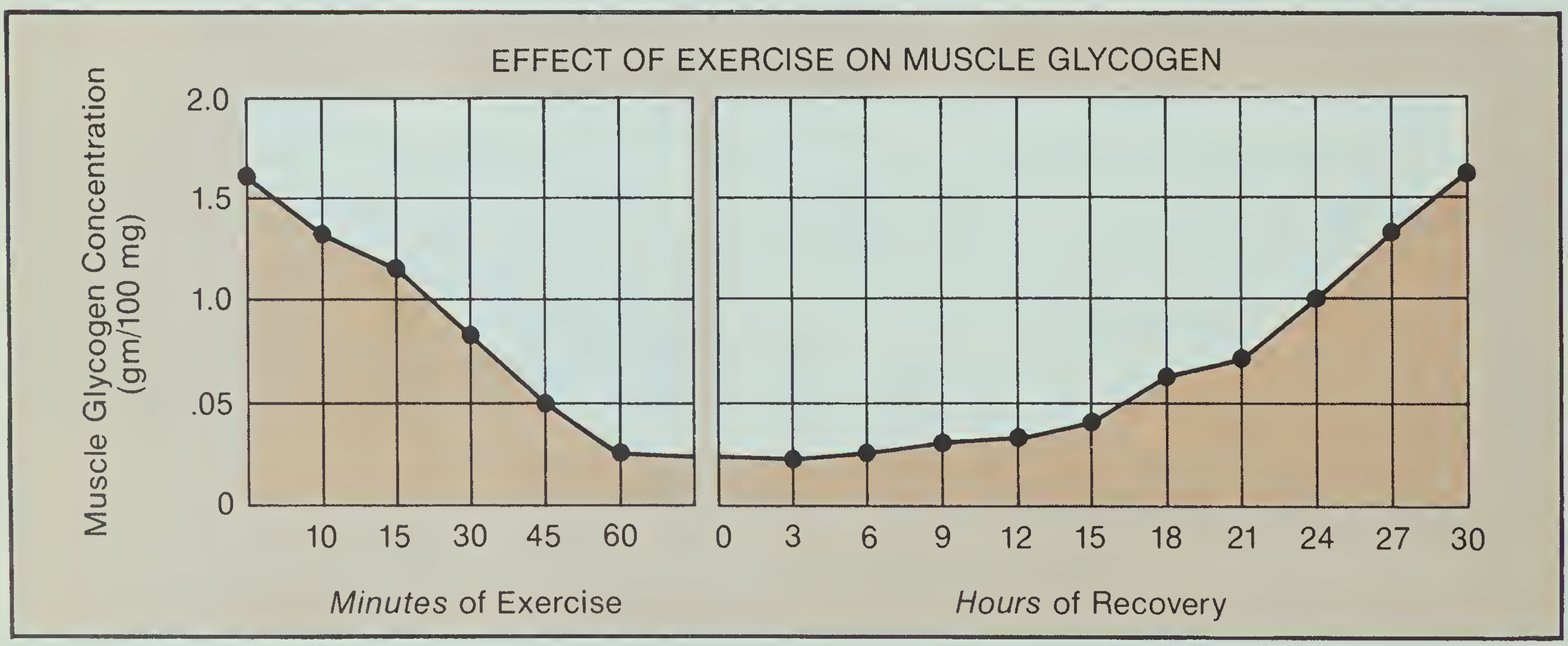
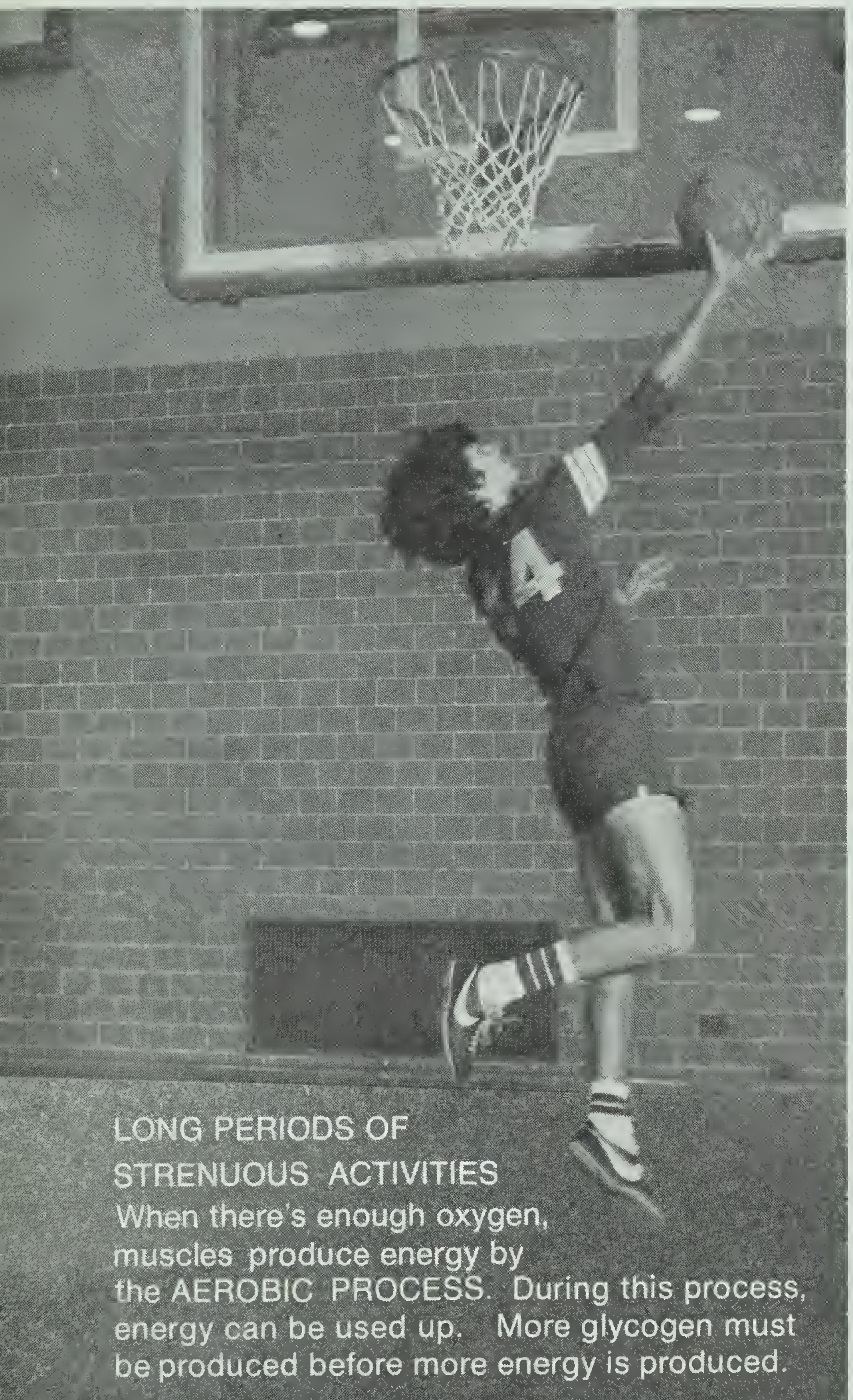


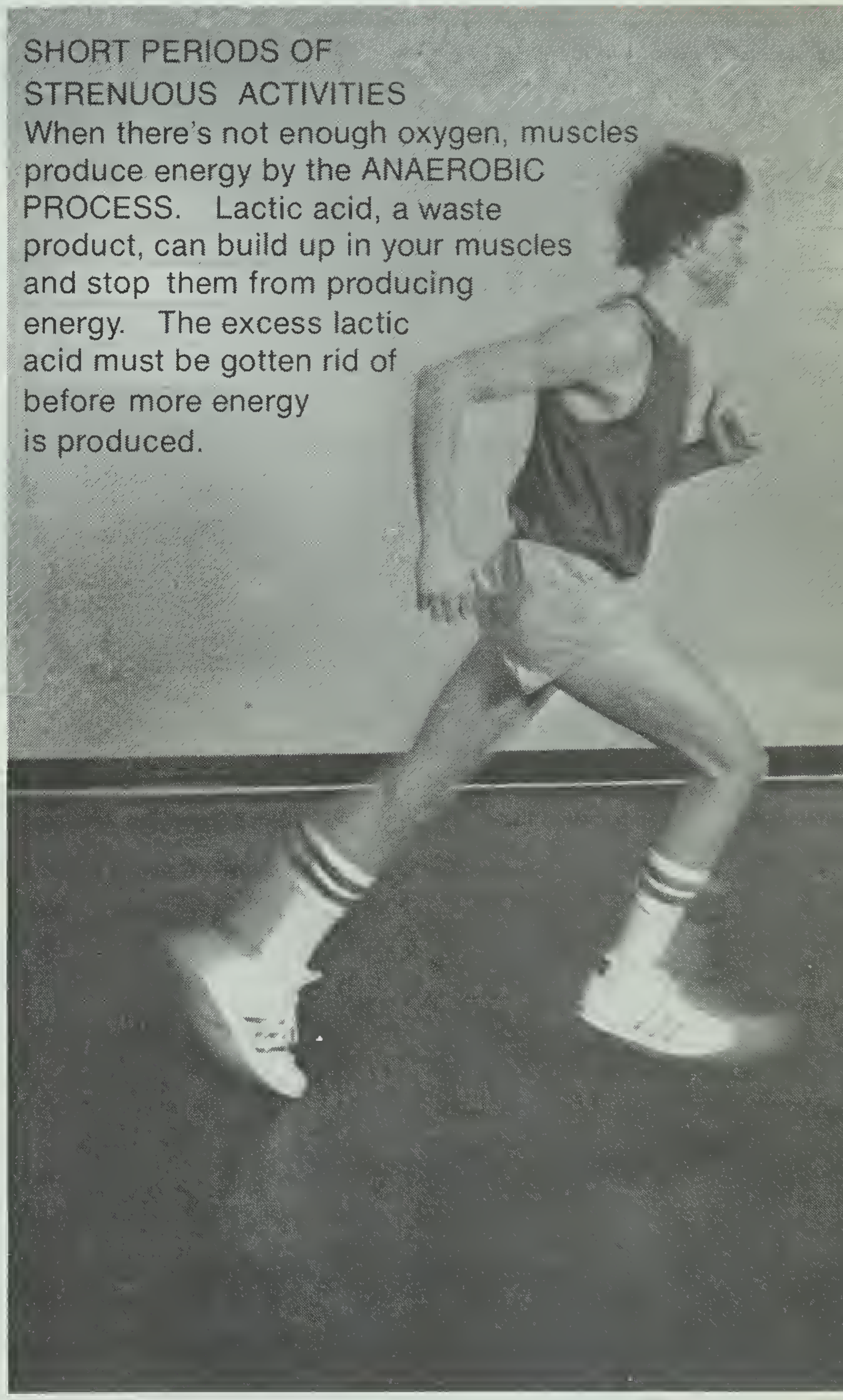
Figure 17-4

• 17-11. Why would you be tired after playing basketball for an hour?

17-11. A lot of the stored glycogen would be used up.

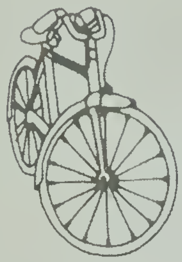
In general, there are two causes of fatigue: the buildup of lactic acid in your muscles, and the depletion of the glycogen in your muscles. It is more difficult and takes longer for your body to rebuild a glycogen supply than to get rid of excess lactic acid. Your muscles must manufacture the additional glycogen from the food you eat.





★ 17-12. Why does it take you longer to recover from fatigue after a long strenuous activity than after a short strenuous activity?

17-12. Because it takes longer for your body to build up a new supply of glycogen than to remove the excess lactic acid.



Activity 18

Excursion Planning

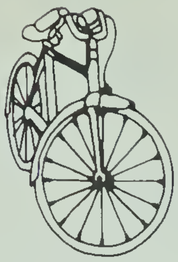
Choosing the Right Activities
Activity 19 Page 71

When planning an exercise program, it's important to choose the right kind of physical activity to do. Not all exercises affect your body in the same way. In this activity, you'll learn how to choose the right type of exercise.

Warming Up
Activity 20 Page 73

Athletes warm up before a game. You too should do warm-up exercises. You'll find out why in this activity.

You'll be doing vigorous exercises in this activity. If you can't do the exercises for health reasons, check with your teacher.



Activity 19
Choosing the Right Activity

ACTIVITY EMPHASIS: How to choose physical activities that develop endurance, strength, and flexibility.

MATERIALS PER LAB GROUP
None.

Choosing the right type of exercise is an important step in keeping fit. Some exercises improve one or two traits. And some exercises improve three traits: endurance, strength, and flexibility. "To be fit" means to do well in all three traits.

Think about the physical activities you do every day — walking, stooping, climbing stairs, etc. Probably these activities do not increase your heart rate enough to improve your endurance.

- 19-1. Why is it good to do more than one type of exercise?

19-1. Most activities do not develop all three physical traits.

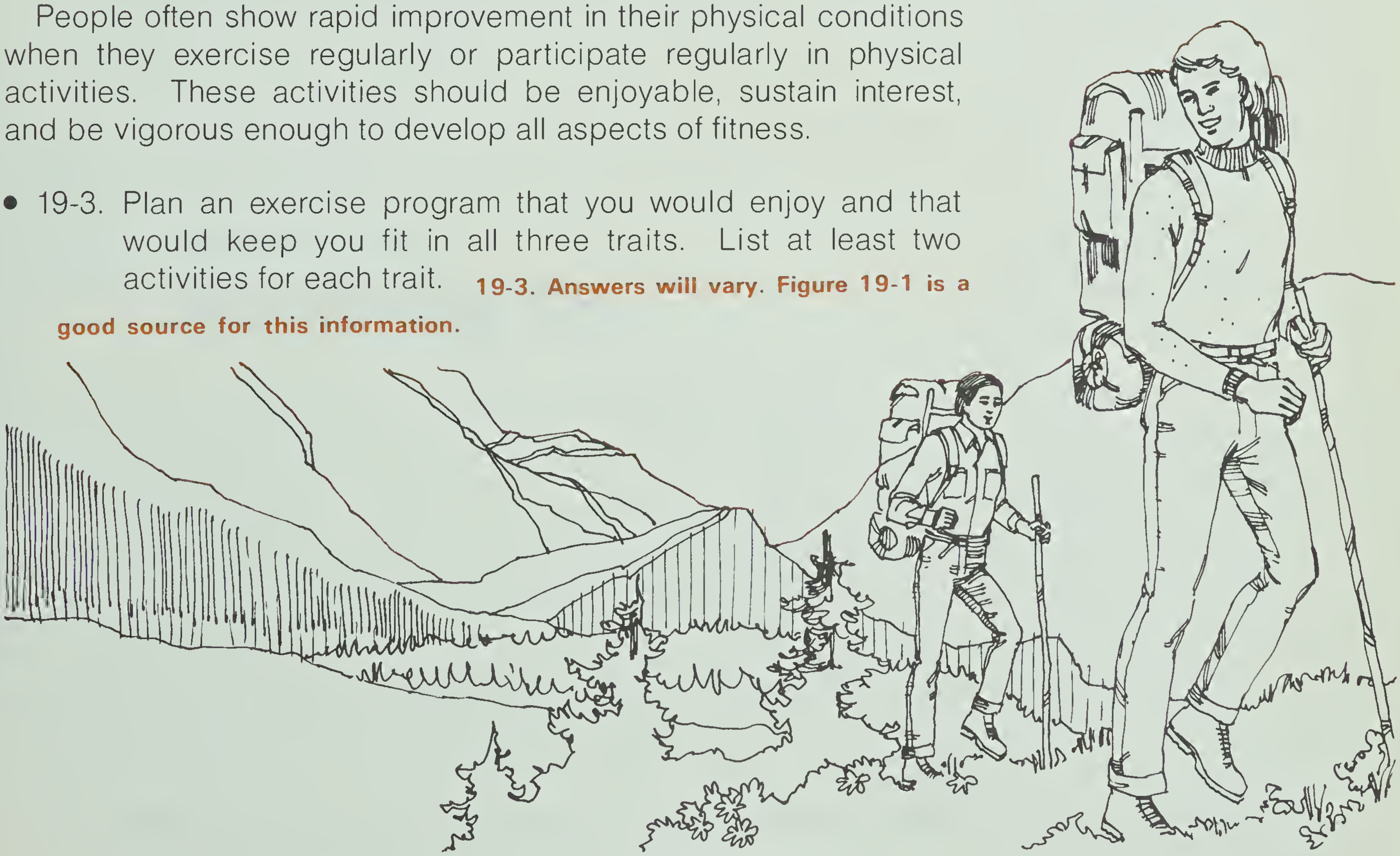
The chart in Figure 19-1 (page 72) lists some physical activities and the traits affected by them.

- 19-2. Look at Figure 19-1 (page 72). List three common physical activities that would give you little or no help in improving endurance, strength, or flexibility.

19-2. Any three of these answers: *bowling, gardening, golf, pool or billiards, softball.*

People often show rapid improvement in their physical conditions when they exercise regularly or participate regularly in physical activities. These activities should be enjoyable, sustain interest, and be vigorous enough to develop all aspects of fitness.

- 19-3. Plan an exercise program that you would enjoy and that would keep you fit in all three traits. List at least two activities for each trait. 19-3. Answers will vary. Figure 19-1 is a good source for this information.



WHAT SOME PHYSICAL ACTIVITIES DO FOR YOU			
	ENDURANCE	STRENGTH	FLEXIBILITY
Archery		★	
Badminton	★		★
Basketball	★		★
Bicycle riding	★	★	
Bowling			
Calisthenics	★	★	★
Canoeing	★	★	
Gardening			
Golf			
Gymnastics		★	★
Handball	★		★
Hiking	★	★	
Horseback riding		★	
Jogging	★		
Lifting heavy things		★	
Long, brisk walk	★		
Mountain climbing	★	★	
Mowing lawn (push-type)	★		
Pool or billiards			
Rowing	★	★	
Skiing	★	★	
Softball			
Square dancing	★		
Swimming	★	★	
Table tennis	★		
Tennis	★		★
Wrestling	★	★	★
Weight lifting		★	
Wood Chopping	★	★	

Figure 19-1

In Figure 19-1, some activities do not affect the physical traits listed. Two examples are bowling and golf. These sports mainly develop coordination — they're called *coordinator sports*.

★ 19-4. Why do you think coordinator sports do not develop a young person's endurance, strength, and flexibility?

19-4. Answers may vary. The basic reason is that coordinator sports are not very strenuous for a young person.

The following questions should help you to determine whether an activity will affect your endurance, strength, or flexibility. The questions are grouped according to trait.

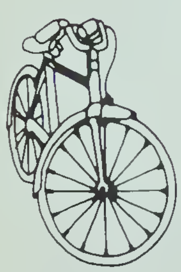
Endurance: Does the activity increase your heart rate to 150 - 175 beats per minute? Does your heart rate stay at the increased rate for a few minutes?

Strength: Does the activity cause enough stress on your muscles? Are there many muscles being strengthened?

Flexibility: Does the activity cause your body to bend and stretch in many directions?

★ 19-5. Soccer is not listed in Figure 19-1. Which physical traits are most improved by soccer? Why? Which physical traits are not improved by soccer? Why?

19-5. Answers may vary. Correct answers are: a. Endurance, flexibility. Soccer is a fast-moving game during which a player's body bends and stretches in many directions. b. Strength. Usually soccer does not cause stress on many of the player's muscles.



ACTIVITY EMPHASIS: The importance of warming up to improve muscular flexibility.

Activity 20
Warming Up

MATERIALS PER LAB GROUP
See Materials and Equipment, pp. TM 3-4.

"Warming up" means doing warm-up (limbering-up) exercises. There are two reasons for doing warm-up exercises before you participate in strenuous physical activities.

To prevent injuries: Warm-up exercises increase your body temperature. As your muscles get warmer, they stretch easier. There's less chance of tearing or pulling your muscles.

To improve performance: Warm-up exercises increase your body temperature. When your body gets warmer, your nerves carry messages to your muscles faster. And chemical reactions in your muscles speed up. (Energy is produced faster.)

In the planning activity, students are directed to check with their teacher if they feel they cannot do vigorous exercises. Rather than leave it up to students to evaluate their health, you might check with the school nurse or the physical education department to see if any students have a medical problem that would preclude their doing the exercises.

★ 20-1. Suppose you are the best player on your team. Why should you still warm up before a game?

20-1. To prevent injuries and to improve my own performance.

Look at Figure 20-1. The graph shows that as body temperature increases, there is an increase in the rate that your body produces energy. (If you have trouble reading the graph, do *Resource Unit 2*.)

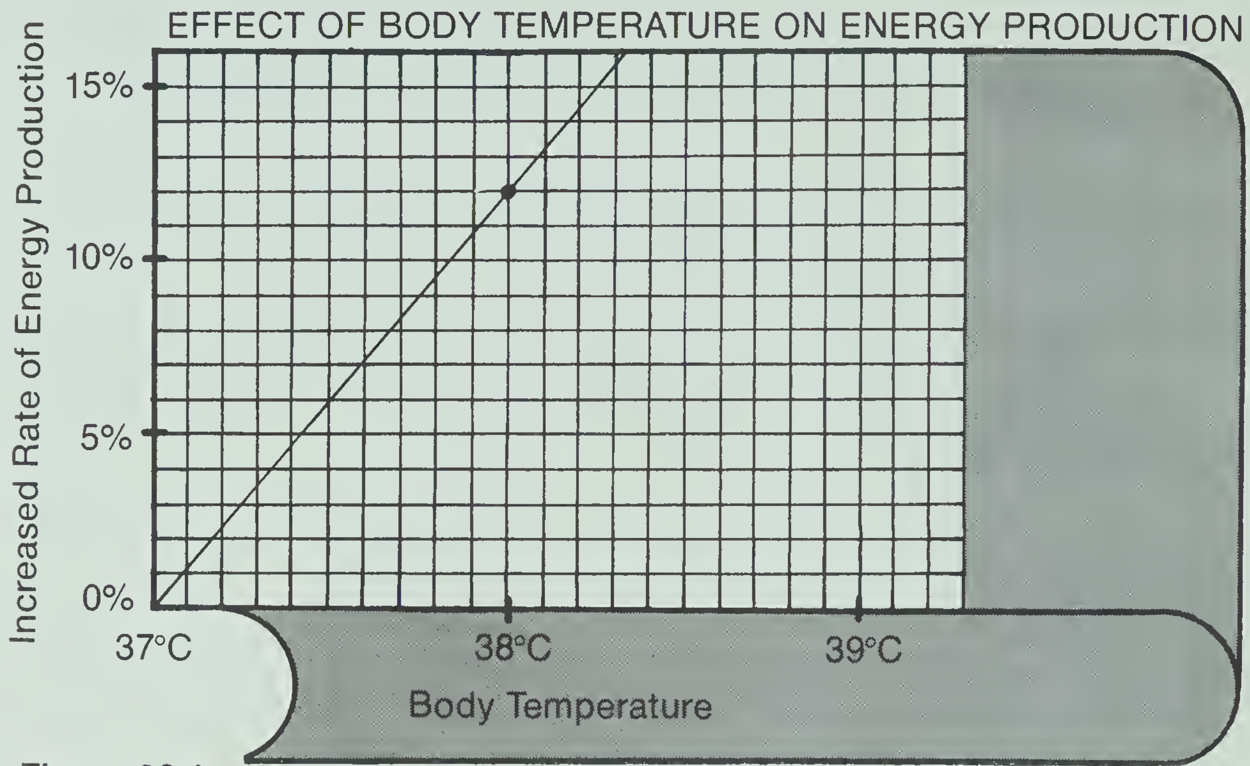


Figure 20-1

20-2. About 12%.

- 20-2. Suppose during warm-up exercises your body temperature increases from 37° C to 38° C. How much will your body increase its rate of energy production? (See Figure 20-1.)

Several factors determine how much your performance will improve by warming up. One factor is *duration* of warm-up exercises. Figure 20-2 shows how the running speed of some athletes is affected by different durations of warm-up exercises.

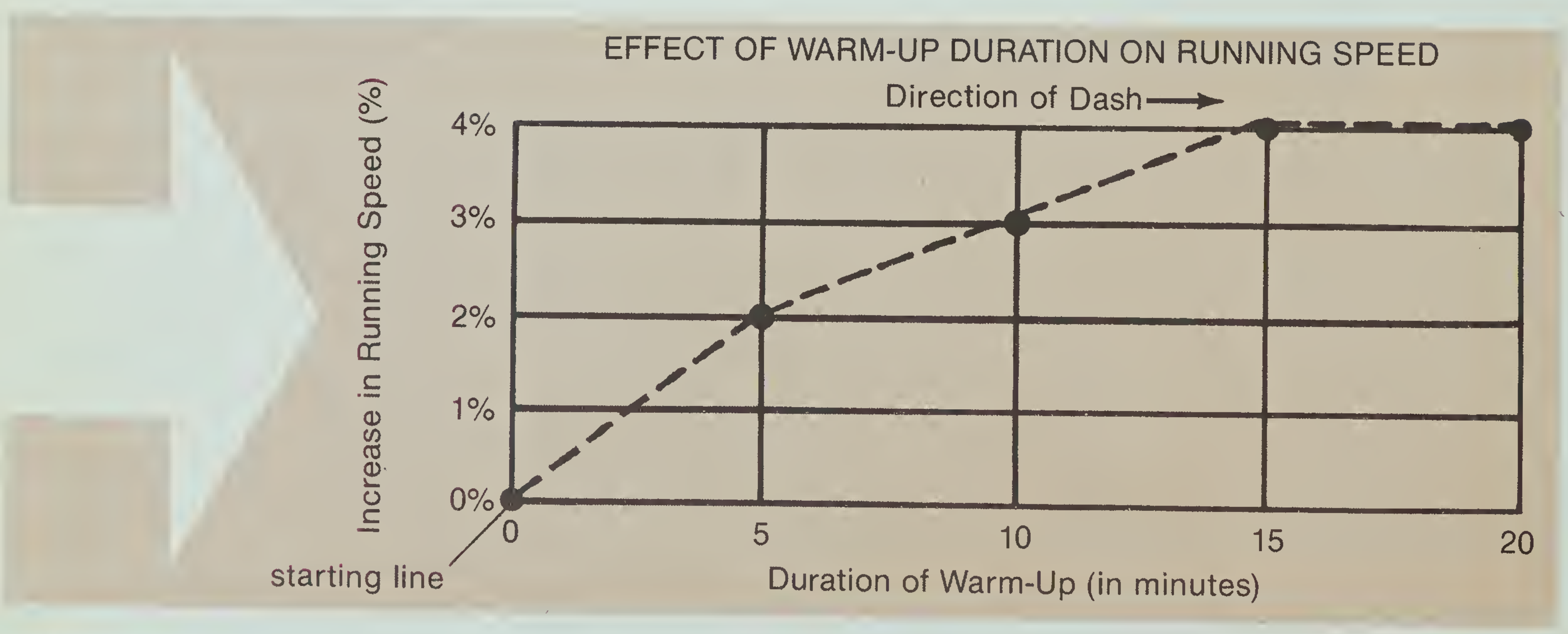


Figure 20-2

• 20-3. Look at Figure 20-2. How was the running speed affected after a warm-up of 5 minutes? 15 minutes? 20 minutes?

20-3. 2% increase; 4% increase; 4% increase

• 20-4. What is the least amount of time that an athlete should spend warming up if she or he wants to be "ready" for a race? Base your answer on the results shown in Figure 20-2.

20-4. 15 minutes

There is no ideal duration for warm-up exercises. The amount of time you spend depends on the activity that you're warming up for and your physical condition. A warm-up period of at least 15 minutes is recommended for physical activities that require a lot of running.

To see how warming up helps your muscles to stretch, try the following investigation. You'll need two partners and the following equipment:

flexibility measuring stick
sturdy chair or bench, the seat 40 cm from the floor
tape
watch or clock with second hand
notebook

The bench or chair must be 40 cm high for validation of results. For directions on preparing the bench, see Advance Preparation for Activity 2, p. TM.5.

You'll have to find some averages in this investigation. Can you find the average for the numbers 3 and 7? If not, do *Resource Unit 1*. (The average for 3 and 7 is 5.)

In your notebook, draw a chart like the one in Figure 20-3. Then turn to the Toe-Touch Test in Activity 4.

A. Do the Toe-Touch Test. Partner 1 holds the chair steady. Partner 2 reads the measurements and makes sure you don't fall. The score from this test is your *Trial 1* score. Record it in the *Before Warm up* part of your chart.

B. Wait about one minute and take the Toe-Touch Test again. Record the score in your chart for *Trial 2*. Average the Trial 1 and 2 scores.

TOE-TOUCH TEST SCORES

BEFORE WARM UP	AFTER WARM UP
Trial 1 ______	Trial 3 ______
Trial 2 ______	Trial 4 ______
Average ______	Average ______

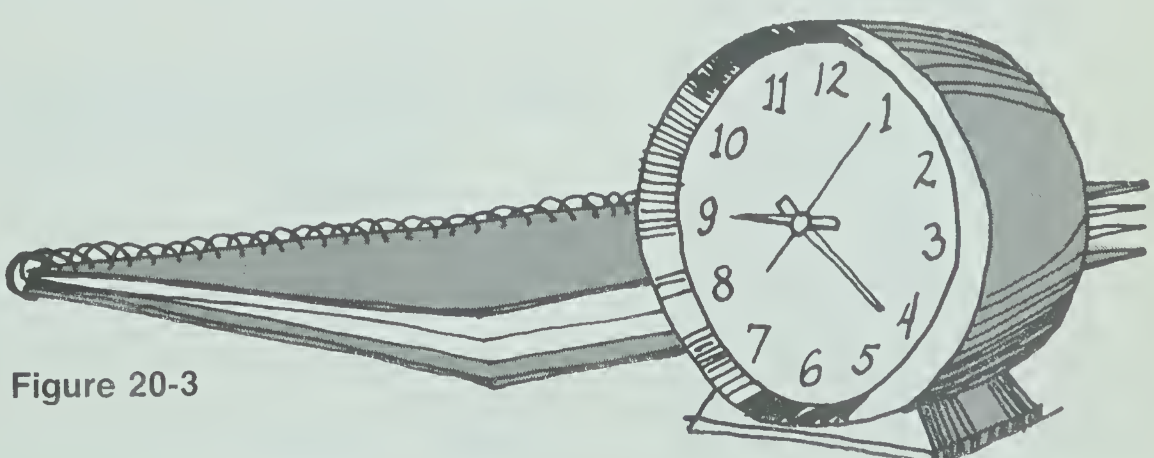
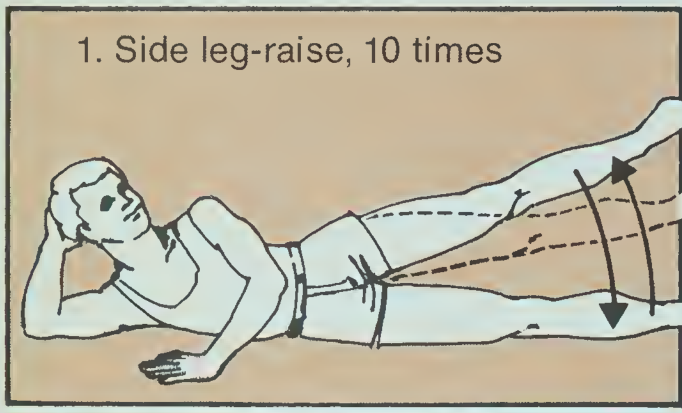


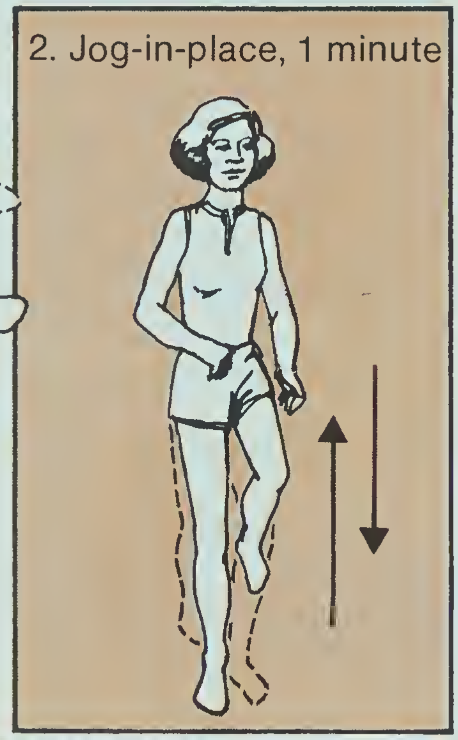
Figure 20-3

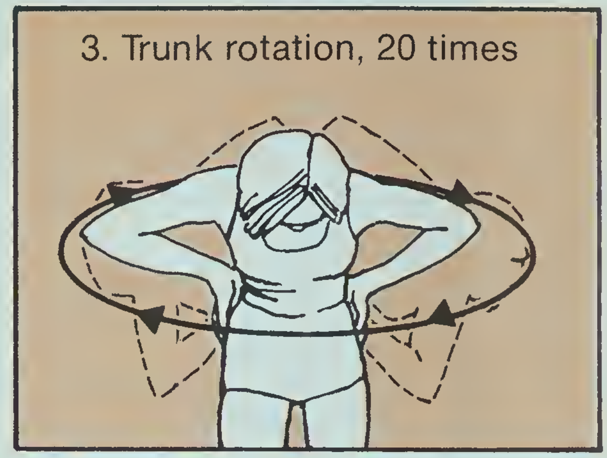
• 20-5. Why is it important to take the Toe-Touch Test two times?

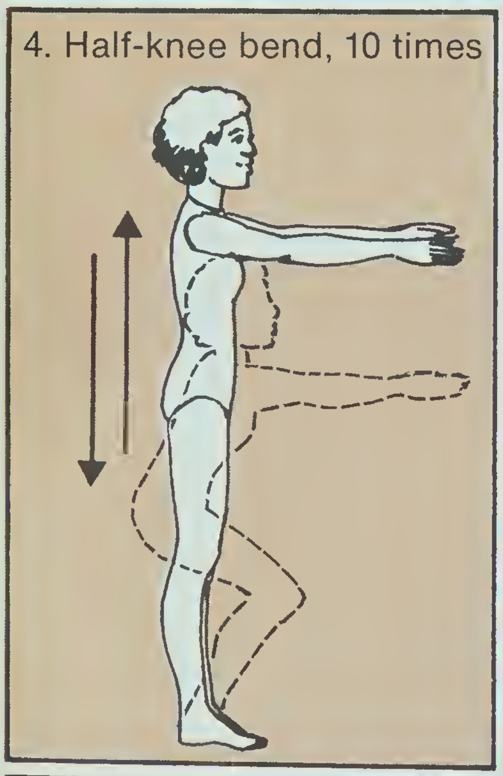
20-5. To account for learning effect. That is, once you know how to take the test, you might get a better score the second time.

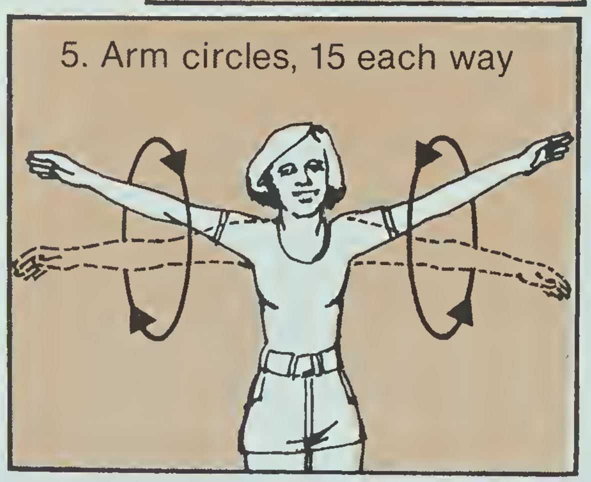
CAUTION **Avoid vigorous exercise right after meals. It may cause stomach discomfort.**











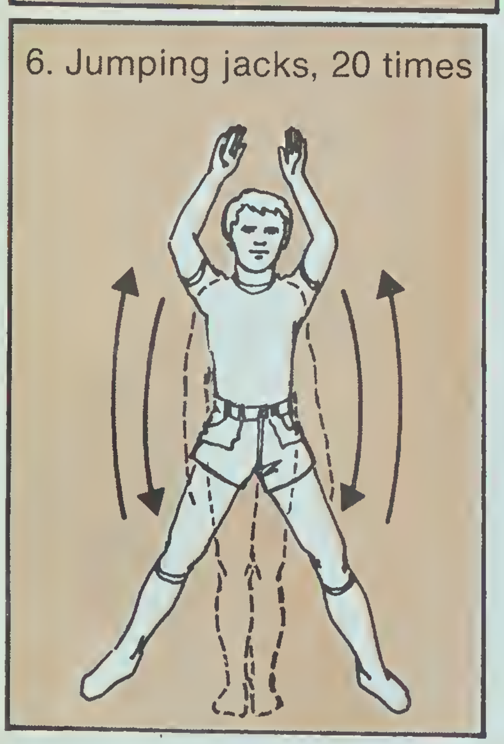


Figure 20-4

C. Now do the six warm-up exercises shown in Figure 20-4. Do the entire set of exercises two times.

D. Repeat the Toe-Touch Test. Record this *Trial 3* score in the *After Warm up* part of your chart. Wait about one minute and take the test again. Record this score in your chart for *Trial 4*. Average the two scores.

Compare your average score before warm up with your average score after warm up.

★ **20-6. How do warm-up exercises affect the flexibility in your legs?**

20-6. The flexibility in your legs increases.

★ **20-7. Suppose you had spent more time warming up. Predict what would have happened to the stretchability of your muscles.**

20-7. They might have stretched more.

● 20-8. What are some other warm-up exercises that you could use?

20-8. Answers will vary. Some answers could be push-ups, sit-ups, and toe-touches.

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